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September 2023 | ₹ 75

Science Reporter

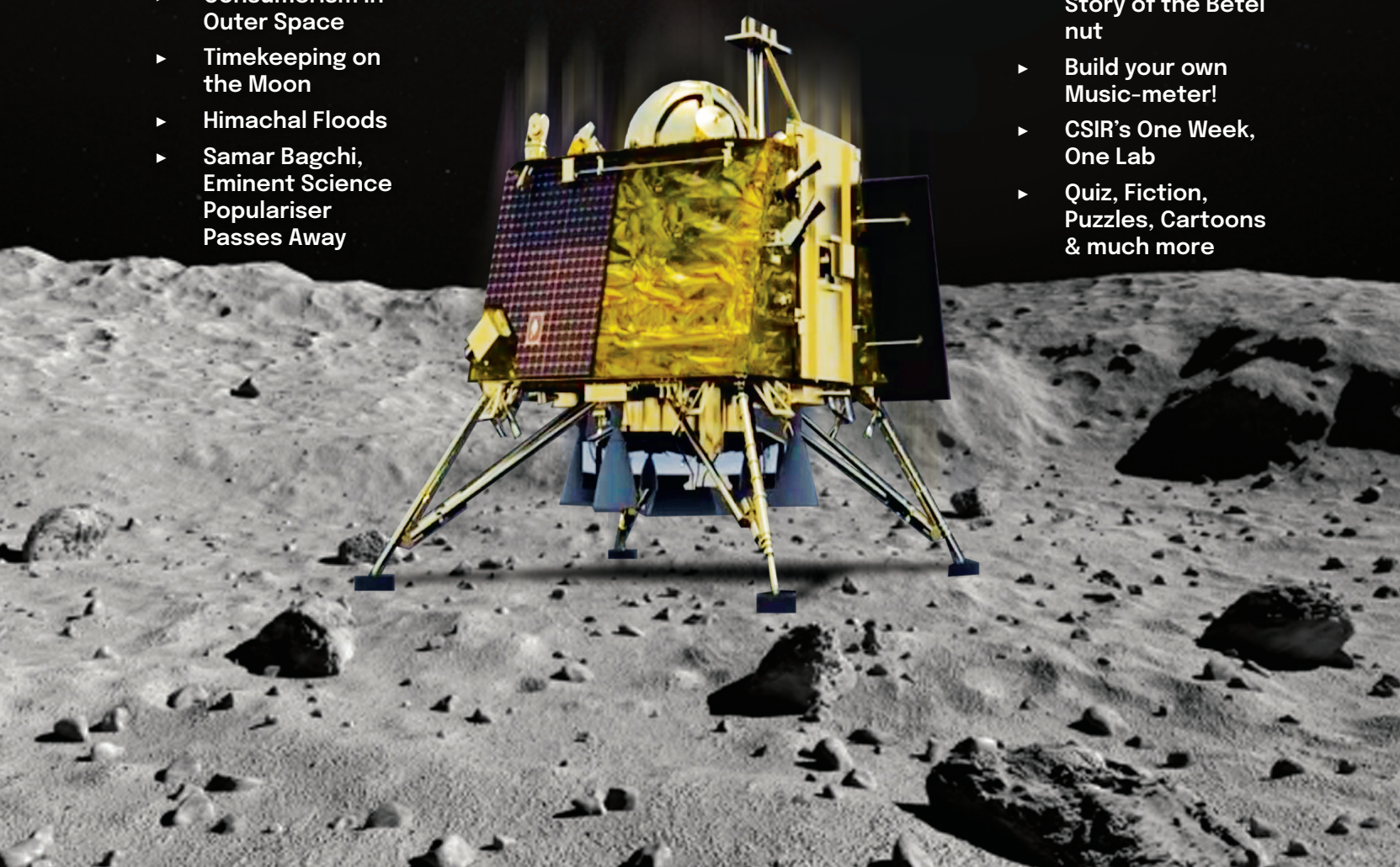
A CSIR Publication

INDIA'S HISTORIC LANDING ON SOUTH POLE OF MOON!

Chandrayaan-3 Safely Lands Vikram lander on Lunar Surface!

Features

- Consumerism in Outer Space
- Timekeeping on the Moon
- Himachal Floods
- Samar Bagchi, Eminent Science Populariser Passes Away
- Unfolding the Story of the Betel nut
- Build your own Music-meter!
- CSIR's One Week, One Lab
- Quiz, Fiction, Puzzles, Cartoons & much more



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EDITORIAL

Chandrayaan-3 Achieves a Historic Feat!

INDIA'S Chandrayaan-3 mission achieved a historic milestone with a safe, soft and precise landing of the spacecraft's Lander on the lunar South Pole! Launched on 14 July 2023, Chandrayaan-3's landing module comprising lander Vikram and rover Pragyan rolled on to lunar soil on 23 August 2023, making India the fourth country — after US, Russia, and China — to achieve the challenging feat due to the Lunar South Pole's rugged terrain with huge craters.

After the successful Chandrayaan-1 Moon mission in 2008, India's Chandrayaan-2 mission in 2019 was another "significant technological leap". However, its attempted soft-landing on the lunar surface was disrupted when the lander Vikram started deviating from its intended trajectory during the Fine Braking phase at ~2.1 kilometres altitude, and crash-landed. Chandrayaan-2's orbiter, however, continues to operate.

But, as they say, failures are stepping stones to success. ISRO's success in achieving a soft-landing of Chandrayaan-3's Vikram lander on the South Pole of the lunar surface is a testament to this. The lander has a number of sensors that ensured a safe touchdown, including an accelerometer, altimeters, Doppler velocimeter, star sensors, inclinometer, touchdown sensor, and cameras for hazard detection and avoidance.

The lander Vikram is box-shaped with four landing legs that absorbed the impact while touching down on the Moon. It has four scientific payloads to perform experiments on the lunar surface. These include a thermal probe Chandra's Surface Thermo-physical Experiment (ChaSTE) to measure the vertical temperature gradient and thermal conductivity near the polar region; Instrument for Lunar Seismic Activity (ILSA), a MEMS-based seismometer to detect minute ground displacement, velocity, or acceleration caused by lunar quakes; and the Laser Retroreflector Array (LRA) to understand the dynamics of the Earth-Moon system.

What happens after the landing? Well, even as you read this issue of *Science Reporter*, the rover Pragyan has descended from the lander to the lunar surface. Pragyan is a mobile laboratory that will collect samples, analyse the geological and chemical composition of the Moon, and identify and determine the abundance of elements near the landing site. The expected operating time of Rover is one lunar day (14 Earth days).

The resounding success of the Chandrayaan-3 mission is a testament to India's unwavering commitment to space exploration and scientific advancement. It is also an inspiration for the nation's youth and countless aspiring scientists, engineers, innovators and entrepreneurs.

Hasan Jawaid Khan

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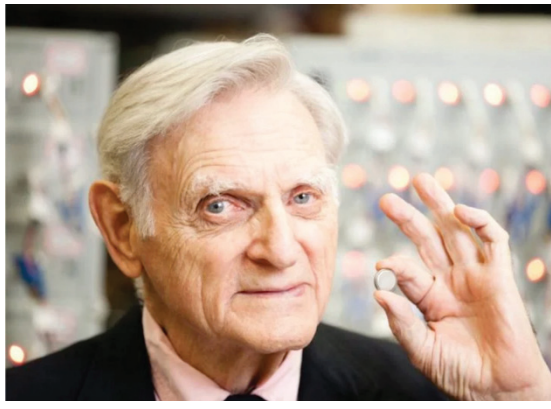
John B Goodenough (1922–2023)
Legend who Revolutionised Electronics Industry is No More



JOHN B Goodenough, a pioneering physicist and materials scientist who revolutionised battery technology, passed away on 25 June 2023. The scientist who created the Lithium-ion (Li-ion) battery, was often described as a "brilliant yet humble inventor". He leaves behind a remarkable legacy of scientific achievements that have transformed the field of energy storage and contributed to advancements in portable electronics, electric vehicles, and renewable energy systems. Goodenough's relentless pursuit of knowledge and his groundbreaking discoveries have left an indelible mark on the scientific community and society as a whole.

Born on 25 July 1922, in Jena, Germany, as the second of four children of Erwin and Helen (Lewis) Goodenough. John, who faced undiagnosed dyslexia, encountered difficulties during his time at local primary schools and was labelled as a student who lagged behind. However, when he became a teenager attending the Groton School in Massachusetts, he adapted to his dyslexia and found ways to manage it.

Reflecting on his experience, he once mentioned, "*In a way, I conquered it. I managed to read in a mechanical manner. To conceal my challenges, I steered clear of subjects like English and history, instead focusing on mathematics and languages, such as six years of Latin and four years of Greek.*" The demanding educational standards at Groton and Yale also provided him with a framework and order in his life, he added.

Goodenough's lifelong journey in the realm of science began with a deep fascination for the mysteries of the physical world. He obtained his bachelor's degree in mathematics from Yale University in 1944 before serving in the US Army during World War II. Following the war, he resumed his studies and earned a PhD in physics from the University of Chicago in 1952. After finishing his education, Goodenough worked at the Massachusetts Institute of Technology throughout the 1950s and 1960s. During that time, he was a member of a team that assisted in the development of ceramic magnetic memory cores that enabled the first Random Access Memory (RAM) in computers. Subsequently, Goodenough moved to Oxford to teach and manage a chemistry lab, where he started his research on batteries.

Throughout his illustrious career, Goodenough held academic positions at prestigious institutions including the University of Chicago, the University of Oxford, and the University of Texas at Austin. It was during his time at the University of Oxford in the 1980s that he made his groundbreaking discovery regarding lithium-ion batteries, for which he is most renowned.

His invention has revolutionised the world by powering smartphones, laptops, and tablets. It has also played a vital role in the development of life-saving medical devices such as cardiac defibrillators. The battery technology has enabled the creation of clean

Green Blood to Fight Cancer!

ARE you baffled about this mysterious green blood? Does it really fight cancer? Does it need to be transfused like regular red blood?

Well, this 'blood' is nothing but wheatgrass juice. And it does not require any transfusions — it can simply be consumed regularly as part of a healthy diet. Wheatgrass (*Triticum aestivum*) is cultivated by soaking wheat seeds in water for a week or two, and then harvesting once they have sprouted. Being young, soft, and greener than a fully grown wheat plant, it has a large amount of chlorophyll pigment, around 70%. This abundance of chlorophyll has earned the nickname "green blood" for wheatgrass juice.

It has a treasure of vitamins (A, B-complex, C, E, and K), minerals (iron, calcium, zinc, potassium, etc.), proteins (arginine, alanine, serine, etc.) and antioxidants. Its immense health benefits in the form of these packed nutrients make it a superfood. It helps to boost the immune system and keeps diseases at bay. It is believed that cooking destroys the nutritional composition of wheatgrass. Hence, it is consumed raw and is also available as supplements like packed juices, powders, and capsules in the markets.

Some scientific studies have shown positive results when the potential of wheatgrass juice was tested against different cancers such as breast cancer, oral cancer, colon cancer, and leukaemia. For example, studies conducted on oral cancer cells and a leukaemia murine model demonstrated that wheatgrass extract can reduce the number of these cancer cells. The high

John B Goodenough receiving his Nobel Prize from HM King Carl XVI Gustaf of Sweden at Konserthuset Stockholm on 10 December 2019.
(Photo credit: © Nobel Media. Photo: Nanaka Adachi)

2019 Chemistry Laureates Akira Yoshino, John B Goodenough and M Stanley Whittingham
(Photo credit: REUTERS)

and quiet plug-in vehicles, including numerous Teslas, which have the potential to reduce the impact of climate change.

Goodenough's seminal contributions to the lithium-ion battery ushered in a new era in the field of energy storage. He and his research group proved that lithium cobalt oxide could be used as a cathode material, which resulted in a notable improvement in energy density in comparison to earlier battery technologies. This discovery paved the door for the creation of the high-energy, yet lightweight, rechargeable batteries that are now commonplace in modern life. It ushered in an energy revolution that now powers practically every portable electronic gadget, ranging from our mobile phones and laptops to medical devices like cardiac defibrillators, and it promises to remove the dependency on fossil fuels through its use in electric and hybrid vehicles.

Recognising the immense impact of his contributions, Goodenough was awarded the Nobel Prize in Chemistry in 2019, along with Stanley Whittingham and Akira Yoshino, two other pioneering scientists who made important contributions to the development of the lithium-ion battery. He was 97 when the Nobel Prize was announced in 2019 — the oldest Nobel Prize winner in history.

Dr Goodenough did not receive any royalties for his work on the battery; instead, he was simply compensated with the pay he had earned as a scientist and professor at the Massachusetts Institute of Technology, Oxford and the University of Texas over the past six decades. He gave away the majority of his rights. He was generous with his patents, sharing them with his coworkers and donating the stipends that came with his awards to support academic research and scholarships.

Beyond his groundbreaking work on battery technology, Goodenough made significant contributions to the field of solid-state physics. His research encompassed the study of magnetic properties in materials, superconductivity, and the exploration of alternative battery chemistries. Dr Goodenough held the Virginia H Cockrell centennial chair in engineering at the University of Texas. He wrote eight books and more than 800 articles for scientific journals. His other major honours included the Japan Prize, the Enrico Fermi Award, the Charles Stark Draper Prize, the Welch Award in Chemistry and the National Medal of Science.

Goodenough remained an active researcher until the end of his life. Recently, Dr Goodenough and his team at the University of Texas had been researching new ways of storing energy, including via a battery made of glass, through a newly launched partnership with Energy Exploration Technologies (EnergyX). Although Prof. Goodenough passed away at the remarkable age of 100, his groundbreaking contributions significantly propelled the world's energy needs.

John B Goodenough will be remembered not only for his exceptional intellect and scientific achievements but also for his humility, perseverance, and unwavering commitment to the betterment of society.

Contributed by Dr Biju Dharmapalan, adjunct faculty at the National Institute of Advanced Studies, Bengaluru-560012.
Email: bijudharmapalan@gmail.com

content of chlorophyll and the structural similarity of chlorophyll to haemoglobin make wheatgrass juice rich in oxygen. Oxygen helps in detoxification of the body and reduces the growth of cancer cells. This is because cancer cells require an oxygen-deprived environment to thrive, so oxygen enrichment of their surroundings works against their development.

Additionally, the rich antioxidant enzymes present in green blood also help in eliminating free radicals. These free radicals are generated daily in our body by cell metabolism. Excessive accumulation of these free radicals in the body leads to health issues including cell damage, ageing, and an increased risk of cancer. Therefore, regular detoxification of the body is essential. In addition, these antioxidant enzymes are great at avoiding DNA damage.

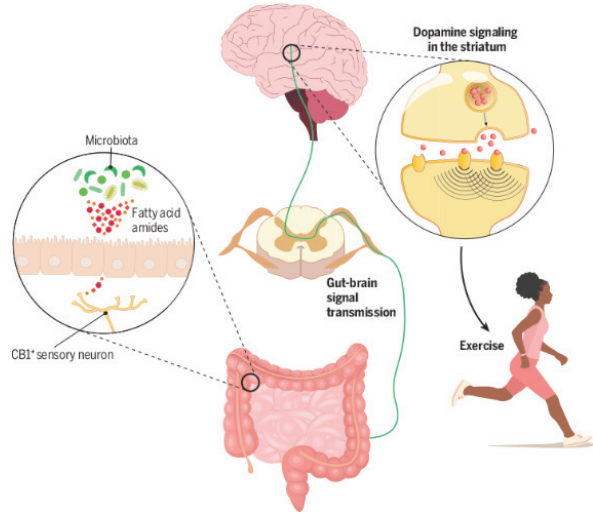
A pilot study of 60 breast cancer patients revealed that those who consumed wheatgrass juice daily had reduced chemotherapy side effects than the control group that received chemotherapy only. Daily intake of the juice also reduced the dose of the anti-cancer drugs in the study. Consequently, combining conventional cancer treatment in tandem with the consumption of wheatgrass juice is beneficial.

However, consuming wheatgrass juice has minor drawbacks as well. These include nausea due to the unpleasant grassy flavour and possible microbial contamination due to early harvesting of wheatgrass.

The evidence related to possible anti-cancer potential of wheatgrass juice is still limited. Further research is likely to provide more information on its efficacy in killing cancer cells.

Contributed by Dr Neema Kumari, Centre for Research Development and Sustenance, Malla Reddy Institute of Medical Sciences, Suraram, Hyderabad-500055

Too Lazy To Exercise? Don't Blame Your Genes



Schematic representation of the role of gut-to-brain pathway that boosts athletic performance.
(Image credit: Thaiss, C.A. Science. 7 July 2023)

IRREFUTABLE evidence suggests that regular exercise helps people combat a host of non-communicable ailments including obesity, enteritis, cardiovascular complications, autoimmune diseases, and some forms of cancers. Exercise is also prescribed as adjunct therapy for overall resilience, improvement of health span and life span.

While there exist health freaks who habitually toil for hours in gyms, most people do not even meet the minimum requirement of weekly 150-300 minutes of moderate to intense workout, recommended by the WHO. Reasons as to why most people find it hard to regularly exercise have been the focus of health researchers for many years.

Christoph A Thaiss at the Perelman School of Medicine, the University of Pennsylvania has recently summarised the researches of his group that show that the gut microbiome of mice plays a seminal role in motivating them to work out on a treadmill (*Science,* 7 July 2023). Microbiome is the collection of all bacteria, fungi and viruses that are associated with the bodies of humans and other animals. Working with large cohorts of out-bred mice, Thaiss and coworkers noticed a remarkable ten-fold difference in exercise capacity among them. Surprisingly differences were unrelated to the genetic makeup of the animals and their genes accounted only for a minor difference in the exercise performance. Variation in gut microbiome however seemed to have a remarkable impact. Mice whose microbiomes were compromised either by making them germ-free or treating them with various antibiotics, revealed nearly halved exercise capacity. Among the many types of bacteria present in the gut of the mice, *Eubacteria* and *Coprococcus* played a greater role in motivating the animals to exercise.

Further investigations revealed that the gut bacteria were primarily affecting the brain of the animals rather than other tissues like the muscles and heart, which are more directly involved in exercise. The bacteria elicited intense neurochemical responses, the most prominent among them was a marked surge in the neurotransmitter dopamine in striatum of brain of the mice. Mice lacking the microbiome showed no such response.

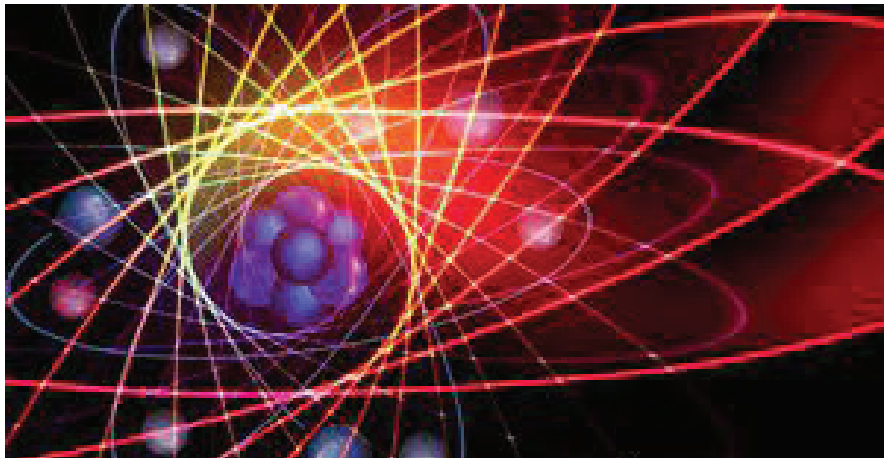
Thaiss and his coworkers further delineated the mechanism by which the bacteria sitting in the gut were influencing the brain function. It turned out that they were producing Fatty Acid Amides (FAAs), most notably the N-oleoylethanolamide, which enhanced sensory neuronal activity through the endocannabinoid-receptor CB1 present in the gut. Binding of the FAAs to CB1 stimulates the dorsal root ganglia to express the gut vanilloid receptor TRPV1 that connects brain through the spine.

The nerve stimulation also results in inhibition of expression of the enzyme monoamine oxidase, which degrades dopamine, resulting in further rise in dopamine in the striatum. It is well recognised that high dopamine levels in striatum of the brain give a feeling of pleasure, motivation and reward and hence enhance athletic performance.

This study has important implications for our understanding of exercise physiology and relationship between the gut bacteria and exercise behavior. Since the gut microbiome can be easily modified, the possibility of transfer of the exercise promoting bacteria from healthy athletes to lazy people seems attractive. Also, those genetically engineered to produce FAAs more efficiently may be used to help motivate people to exercise.

Contributed by Prof. M Saleemuddin, former faculty of AMU, Aligarh. Address: My Home Glory Apartments, Masab Tank, Hyderabad, Telangana State.

Chiral Bose-Liquid: A New State of Matter



Chiral Bose-liquid state (A representational image)

IN our daily life we come across three states of matter — solid, liquid and gaseous. However, at temperatures approaching absolute zero or within the atom things are quite different — the matter enters the realm of quantum state, where its behaviour becomes vastly different from what we experience in our macroscopic world.

Physicists call it "frustrated quantum system", where infinite possibilities result from the interaction of particles and some of these infinite possibilities can lead to novel quantum states of matter. As for example, Tigran Sedrakyan of the University of Massachusetts (US) and his co-workers have reported in *Nature* (14 June 2023) — they have engineered a frustration machine, a bilayer semi-conducting device, whose top layer is electron rich and these electrons can move freely, while the bottom layer contains "holes" or places that roving electrons can occupy.

When the two layers are brought in very close proximity the machine triggers to create a local imbalance resulting in the electrons not having enough holes to file. As a result, the Chiral Bose-liquid state, a new state of matter is created. The term "Chiral" has been used because the electrons in the Chiral Bose-liquid state move or behave differently as compared to their mirror-image counter-parts, leading to unique and asymmetric characteristics. It is from a Greek word for "hand" which refers to anything that cannot be superimposed on its mirror image.

In this state, electrons exhibit unique properties and behaviours. They can freeze into predictable patterns making them highly organised as well as synchronised and resilient to change spin, which is a defining characteristic of subatomic particles. They even remain unaffected by collision with other particles or the introduction of magnetic field. A particularly intriguing aspect of the Chiral Bose-liquid state is the collective behaviour of its particles when an external particle collides with one of them. Instead of behaving individually, all the particles react in the same way, a phenomenon attributed to the long range entanglement present in this quantum system.

Observing the elusive Chiral Bose-liquid state has proven to be a formidable task due to its inherent complexities. To overcome the obstacle, a team of Chinese physicists including Rui Wang, Baigeng Wang and Lingjie Due of the Nanjing University and Rui-Rui DU of the Peking University devised an experiment that utilised an extremely strong magnetic field, which allowed them to track the movement of the electrons. This innovative approach enabled the measurement of electron movements as they engage in their dynamic interactions.

According to Lingjie Due, the semi-conductor bi-layer's edge experiences helical-like transport because electrons and holes are moving at the same speed there. This transport behaviour could be further modulated by external magnetic fields gradually separating electron and hole-channels under higher fields.

These magneto-transport experiments by the researchers successfully revealed the first concrete proof of the Chiral Bose-liquid state, also known as the "exitonic topological order". It sheds light on the fascinating behaviour of matter under extreme quantum condition, while opening new possibilities for harnessing quantum phenomena for research and practical applications, including the development of advanced digital encryption systems, opening doors to advancements in information technology and cryptography.

Contributed by Dr Ramesh Chandra Parida, Retd Professor of Chemistry, Odisha University of Agriculture and Technology, Usha Nivas, 124/2445, Khandagiri Vihar, Bhubaneswar-751030. Email: paridanana47@gmail.com

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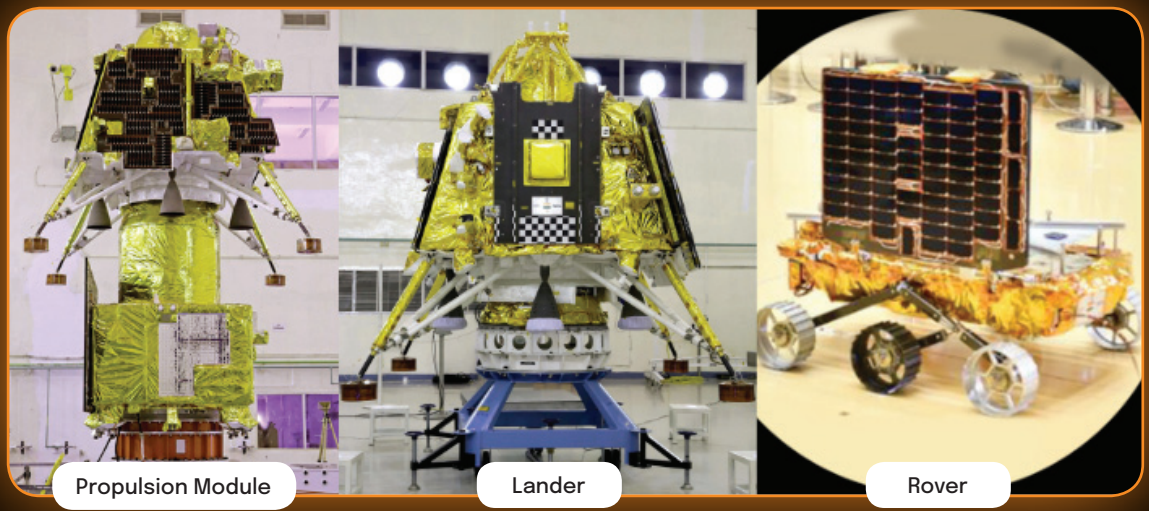
HISTORIC MOMENT FOR INDIA!

Chandrayaan-3 Mission Successful — Vikram Lander Soft-lands on the Moon

India becomes the first country to land on the South Pole of the Moon

Chandrayaan-3 — India's Pride

Chandrayaan-3 comprises a Lander Module (LM), Propulsion Module (PM) and a Rover with the objective of developing and demonstrating new technologies required for interplanetary missions.



Objectives of Chandrayaan-3 mission

1. To demonstrate safe and soft landing on lunar surface
2. To demonstrate Rover roving on the moon and
3. To conduct *in-situ* scientific experiments.

Major scientific experiments planned

1. Vibrations on the lunar surface due to seismic events, and/or due to the impact of meteorites, rover movement, etc.
2. Near-surface plasma environment
3. Temperature and thermal conductivity up to the depth of 10 cm elemental composition in and around the landing site
4. Spectral signatures of Earth from lunar orbit.

5 July 2023

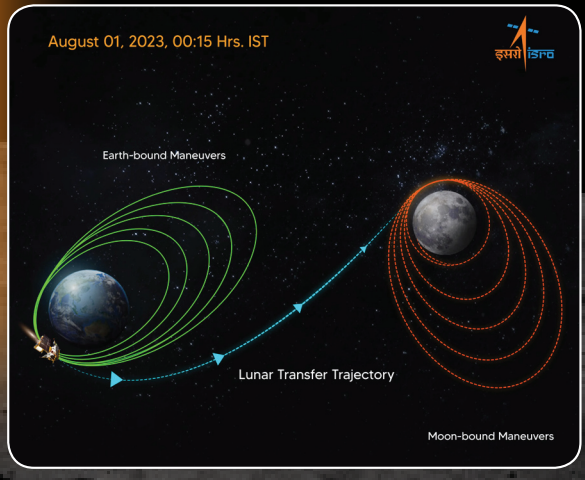
Encapsulated assembly containing Chandrayaan-3 attached with the launcher LVM3 at Satish Dhawan Space Centre, Sriharikota.

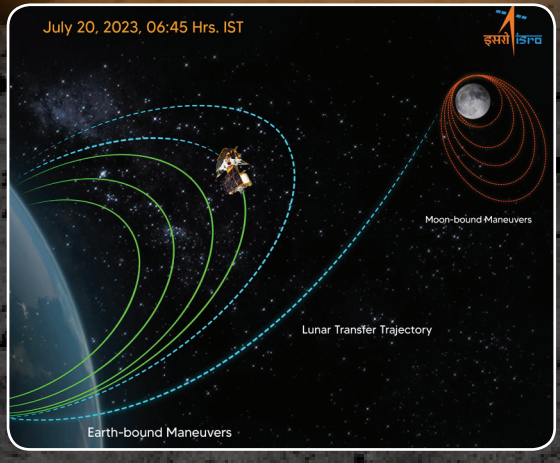
7 July 2023

Final stage of preparation for the launch commenced with the movement of the LVM3-M4 vehicle to the launch pad — vehicle electrical tests were completed.

14 July 2023

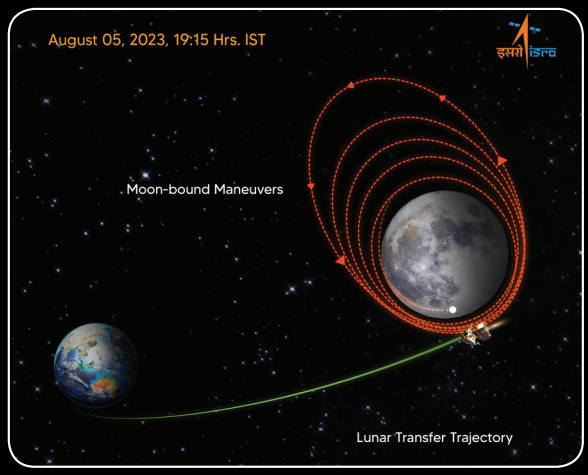
LVM3 M4 vehicle successfully launches Chandrayaan-3 into lunar orbit. Subsequently, a series of orbit-raising manoeuvres were performed, finally inserting the spacecraft into the translunar orbit on 1 August.





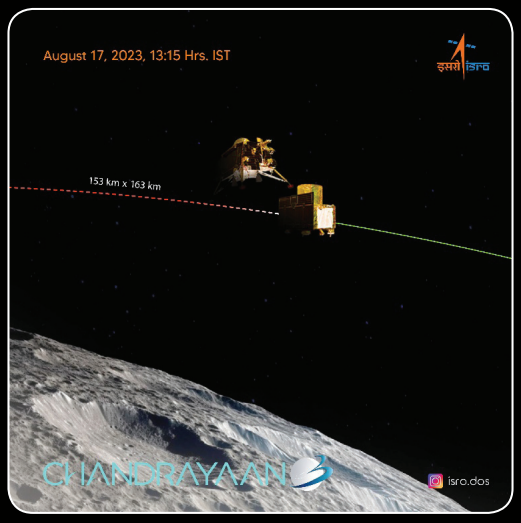
5 August 2023

Achieving a major milestone, Chandrayaan-3 successfully inserts into the lunar orbit which marks the third consecutive success for ISRO to enter the lunar orbit.



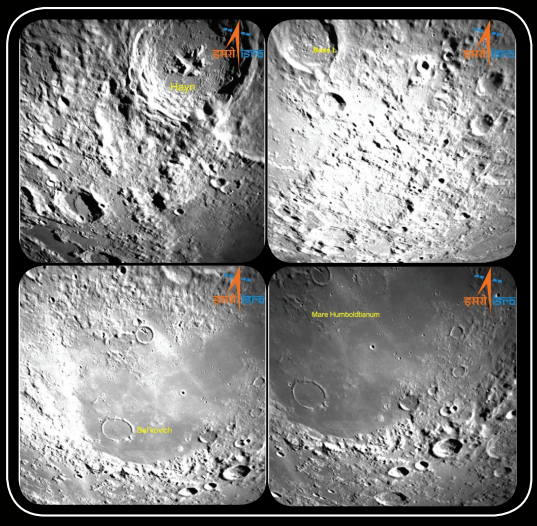
17 August 2023

Yet another key step — Lander Module successfully separates from the Propulsion Module.



19 August 2023

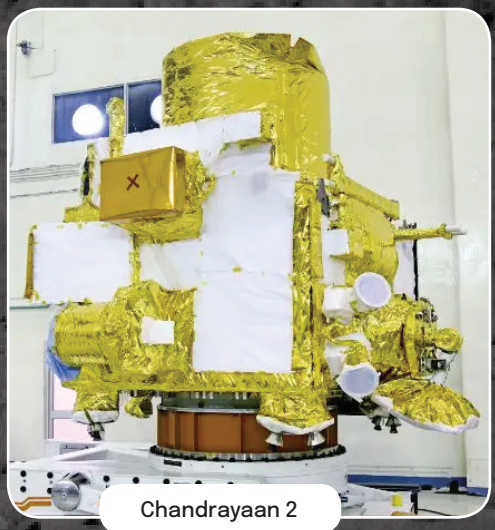
Lunar far side area captured by the Lander Hazard Detection and Avoidance Camera (LHDAC).



21 August 2023

'Welcome, buddy!'

Chandrayaan-2 orbiter formally welcomes Chandrayaan-3 LM establishing two-way communication.


Chandrayaan 2

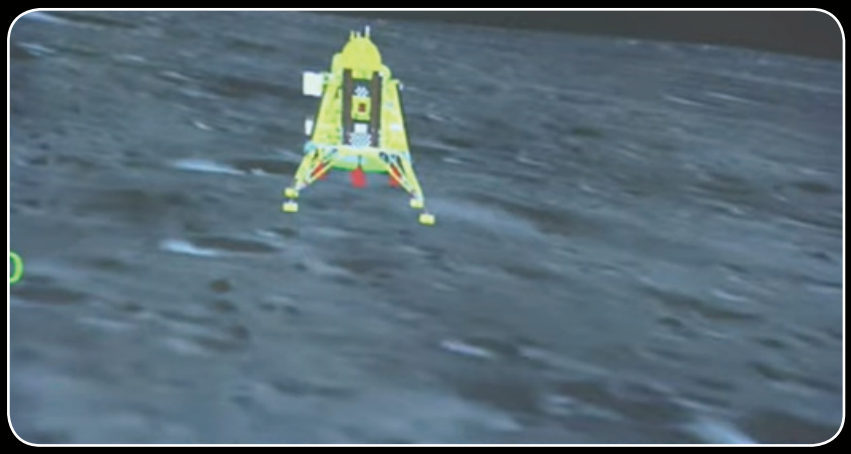
Chandrayaan 3

Cyclic nature of scales

23 August 2023

India Creates History!

Chandrayaan-3 successfully soft-lands Vikram Lander on the South Pole of the Moon — the first time any country in the world has managed to achieve. The lunar South Pole has never been explored.

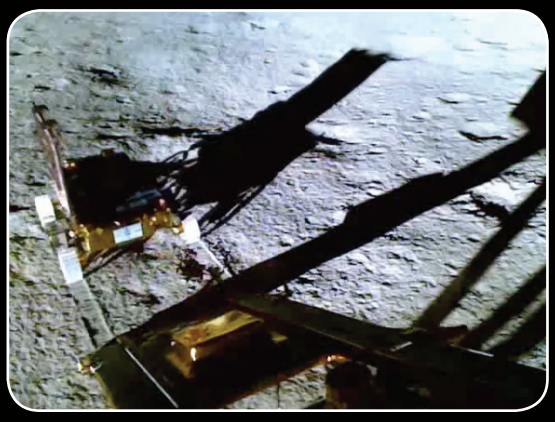


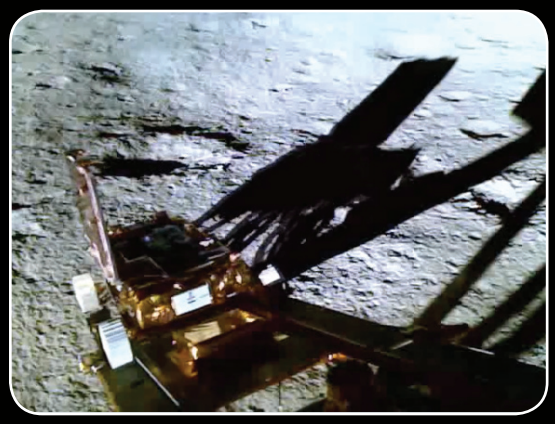
23 August 2023

Photograph of a portion of the Chandrayaan-3's landing site taken after the landing.

24 August 2023

Chandrayaan-3 Rover Pragyan rolled down from the Lander. Pragyan begins making observations and collecting scientific data





"Historic day for India's space sector. Congratulations to ISRO for the remarkable success of the Chandrayaan-3 lunar mission."

Honb'le Shri Narendra Modi, Prime Minister of India (Tweeted)

"Thank you, India, for the overwhelming support!
A euphoric moment, like never before, when Chandrayaan-3 touched the surface of the Moon. From senior citizens to young children, all waited with equal enthusiasm to see history in the making."

Hon'ble Dr Jitendra Singh, S&T Minister and Vice President of CSIR (Tweeted)

During the celebration of the landing moment of Chandrayaan-3 at CSIR Headquarters.

CSIR's Wind Tunnel Testing Facility carried out more than 3000 Wind Tunnel Tests to characterise the LVM 3 vehicle
1.2m Trisonic Wind Tunnel of CSIR-National Aerospace Laboratories (CSIR-NAL), Bengaluru

"CSIR is proud to have been associated with the ISRO for the Wind Tunnel Testing of the launch vehicle at CSIR-NAL, Bengaluru."

CSIR (Tweeted)

"Each of the Space programmes has been a resolute national mission, involving a select few directly, but thousands indirectly or remotely. Every contributor plays a crucial role, making them all key functionaries. In the case of CH-3, numerous science streams, academics, industries, and PSUs have actively participated. As this significant mission unfolds, we carry the heartfelt wishes of billions, united in their hopes for its resounding success."
Mr Somanath S, Chairman, ISRO

Information courtesy ISRO

CONSUMERISM IN OUTER SPACE

IS IT SUSTAINABLE?

Paresh R Vaidya

Space technology and space exploration are critical to human progress. However, the recent increasing thrust on space tourism could pose dangers to space exploration for scientific advancements.

Image Credit: pxfuel

IN March this year, the Indian Space Research Organisation (ISRO) placed 36 satellites into a medium orbit for a British company OneWeb. The company plans to have 648 satellites in the sky to provide internet services. However, OneWeb, partner of our Bharati Airtel, is not the first one to accomplish this. Amazon has come up with its own Kuiper project. The US based entrepreneur SpaceX has planned to offer internet services using a whopping 42000 satellites! To get a feel of the enormity of this figure, consider that presently only 4300 satellites are floating up there, for *all the purposes* and for *all* the countries. The question to be asked: Is this overkill sustainable or even desirable?

A similar consumerist thrust is visible in another activity related to Space — Space Tourism. SpaceX and other space technology companies have been testing their ideas. The year 2021 was an eventful year when three of the giant Corporates sent men in space in spaceships of their own designs. The effort aims at converting space travel from a fantasy into reality, even if it is at a huge price. With a dozen of ordinary citizens having touched or crossed the Space boundary within a year, it is a reality to reckon with.

The Virgin Galactic began to make reservations for space tour a long time ago. They have a waiting list of 600 tourists who would pay US Dollars 2,50,000. India's Santosh George Kulangar is also one of them, since 2008, having committed his two crore rupees for the purpose. Travel to space exposes astronauts to ionising radiation and there is no protection against it. But the short travel of these tourists is not likely to inflict any such harm. The tourists will not be insured against *any threat or accident!* They have given the undertaking that they are going at their own risk.

The Blue Origin of Bezzos has operated six flights so far and were planning to resume the activities by May this year after a pause. The tech-savvy segment of the population received the developments enthusiastically when they were served the news by the excited television channels and the print media. Encouraged by these responses, some more business ventures have been announced like a privately owned Space Station, a hotel in the orbit and so on.

All these events are harbingers of a shift in paradigm. So far activities in Space were undertaken only by nation States and therefore presumed to be for the welfare of their subjects or for humankind at large. Business was not on anyone's agenda. In fact, the Outer Space Treaty of the United Nations (Article I) opens with these words: *"The exploration and use of outer space, including the Moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind."*

It was known that all the nations used the knowledge gained during these experiments for some defence-related objectives too, like the Global Positioning Systems (GPS), but the outcome was not intended to be for personal gain or corporate profit. While the general population was permitted to use the spare capacity of the GPS satellites, the excitement seen during the experimental flights for tourism,

2021 and Space Odysseys

The year 2021 was the year of hectic activity for Space Tourism experiments. With a dozen people having touched or crossed the space boundary within a year, it is an example of how competition works. American businessman Jeff Bezos did it on 20 July 2021, the anniversary of the first moon landing. Another of his ilk, Richard Branson created a surprise and beat him in the game by ten days in a sudden sojourn. Elon Musk did not fly himself but sponsored the journey of William Shatner, the nonagenarian hero of the famous television serial *Start Trek*, in October the same year.

All these teams took sub-orbital flights, meaning that they did not encircle the Earth but just touched the space boundary. However, the fourth team of four tourists, set up by the SpaceX, did fly into an orbit on payment, in September 2021; none of the four was an astronaut.

Year 2021 has a distinction of a different kind too — that of collisions. A Russian communication satellite and a satellite from Iridium constellation (GPS service provider) collided in February. Fearing a collision with Starlink satellite, China had to change the course of their Space Station — they even took the matter to the UN General Assembly. And when Russians tested their satellite destruction device, the crew of ISS had to take shelter in the transport craft.

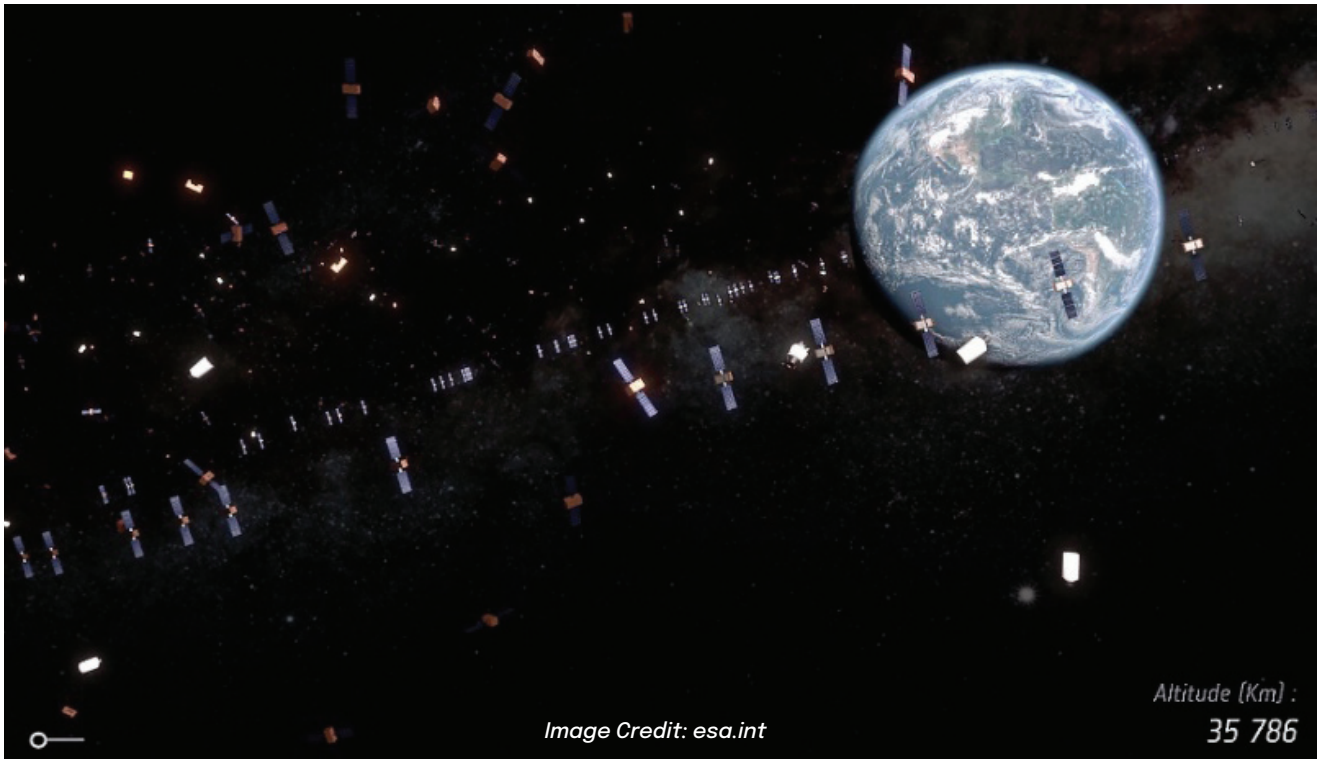


Image Credit: esa.int

was not about the technology but on account of opening of the avenues of consumerism. Now anyone with money can board a spacecraft and experience weightlessness without any rigorous training. Or get a superfast 5G or 6G internet connectivity using Starlink chain of satellites.

These may look like egalitarian gains, but one must not also overlook the fact that once a technology enters the societal domain, it proliferates uncontrollably, often with menacing dimensions and directions. There are numerous examples in the past to buttress this argument.

Primarily, there are three areas of concern related to the consumerist application of Space — the issue of Space debris; legal and regulatory concerns, and the likely impact on the environment. Let us examine each of them in the light of present knowledge and future projection.

Space Debris

Space debris, also called space junk, comprises non-functional objects in orbits and includes a very wide variety of materials. They could be abandoned satellites, empty rocket shells discarded during launch, fragments from the exploded rocket motors, tools and devices lost during repair work on space stations or space walks and numerous other miscellaneous articles. Though very rare, some collisions also have happened in space, creating newer pieces of every size from a millimeter to metres.

Image Credit: flicker

The European Space Agency has estimated that there are 36000 large (>10 cm) objects which are trackable. Pieces smaller than 10 cm, down to one centimeter, may be a million and smaller than a centimeter would run into tens of millions. Those in the lower orbits descend further down due to air drag and eventually burn down, but those in higher orbits keep flying undisturbed. All of them travel at very high speed, varying with the orbit diameter, with the highest speed of 7 km/sec (i.e. 25000 kmph!) for the Low Earth Orbit (LEO). They carry enormous momentum even if small in size and are a big threat to satellites.

This is the current situation with the legacy of only 11670 satellites launched so far in sixty years. One can imagine the chaos if another one lakh satellites are positioned there for internet and other purposes as the business heats up and then them being continuously replaced every 5 to 8 years. Their own population density will be competing with that of the debris and hence the chances of collision increase. Way back in 1978, Prof. Donald Kessler had predicted this overcrowding, now named as Kessler Syndrome.

Environmental Damage

There is hardly any technological activity that is environmentally neutral — space too is not an exception.

Two concerns need to be evaluated — carbon emission and Ozone depletion. A significant component of carbon footprint would come from the rocket propulsion apart from the manufacturing processes. A large variety of propellant fuels is used as per the design and size of the rockets. The simplest liquid propellant is RP-1, akin to kerosene. Methane and hydrazine variants are also organic compounds and have clearly defined carbon dioxide emissions.

The solid propellants include complex molecules like PBAN or HTPB where PB indicates Poly Butadiene. Ammonium per chlorate and powders of aluminium and magnesium are dispersed into solid propellants for specific roles. Though carbon free, being aerosols, they influence albedo (heat reflection) as they get dispersed into air and space when the rocket has completed burning. Advanced cryogenic

Image Credit: pxfuel

engines use Liquid Oxygen (LOx) and Liquid Hydrogen (LH) as propellants and create water as residue. This is hailed as carbon free but one should not miss the fact that these liquefied gases are produced and stored at very low temperatures (LOx at -180^0C and LH at -250^0C). The enormous energy required to accomplish this produces carbon dioxide.

The carbon emission depends upon the nature of fuel and the design specifics of the rocket, linked to the thrust generated. Higher the payload weight or the aimed altitude, higher will be the thrust required. The range is very wide. The famous Atlas rocket emits 260 tons in a flight whereas Falcon 9 and Starship (both used in Space tourism flights in 2021) emit 425 and 710 tons of carbon dioxide respectively. Compare it with the emission of a commercial aircraft, which gives out typically about 100 tons. But the number of flights for all the three genres is different. The commercial aircraft flights are way more than all the rocket launches together. So the emissions from the space segment do not seem to hurt much on relative terms.

But the scene can change faster than expected in future if the tours to space increase. In such a case we need to compare emissions *per passenger* carried by the vehicle. When a spacecraft is used as a vehicle to carry tourists, comparison between a launch vehicle and an aircraft is not out of place. An aircraft carries 200 to 400 passengers for the carbon emission of 100 (or maximum 200) tons i.e. 500 kg of CO_2 per passenger. In contrast, orbital/sub-orbital flights carry very few passengers. Three passengers who went in Soyuz or four in Falcon 9, works out to be respectively 80 and 105 tons per passenger! This per capita environmental cost is just for experiencing weightlessness for only 5 to 10 minutes.

Even if the future flights carry more passengers, the per capita statistics would not change much because the economy of scale does not work here. Every added payload weight needs additional fuel, more than proportionately. Rockets need to achieve acceleration to escape Earth's gravity. Aircraft also has to fly against gravity but it benefits from its speed during take-off due to aerodynamic lift. Rockets are not designed on these principles. Virgin Galactic did use an aircraft for take-off but it has to be seen how it performs at higher load. When the United Nations Framework Convention for Climate Change (UNFCC) is struggling to convince people to reduce every kilogram of carbon from the atmosphere, these romantic adventures can become the last straw on a camel's back.

Emissions from space rockets are beyond troposphere where thermal mixing of air is not dominant; this allows the pollutants to stay there and make impact for longer time. The same can be said about the water produced during a cryo-engine flight as water too is a greenhouse gas. It will not be able to take part in weather processes from there and thus precipitate soon. Higher temperatures obtained during rocket burn produces higher amounts of oxides of nitrogen; they neutralise the ozone layer which has shown signs of getting repaired to some extent after the Montreal Protocol, a collective hard work of the international community. The reusable structures (on which there is an emphasis in the tourism segment) produce NOx gases even during reentry phase and thus do additional harm.

Legal Issues

The legal aspect is specific to space tourism. Presently, air travel and space travel are governed by different international laws. For air travel, there is the Warsaw Convention with elaborate provisions to determine liability in different situations. In case of any accident or damage, the airline is supposed to compensate.

However if the damage occurs due to a space object, the liability is taken up by the nation. The rationale behind this so far was that the space journeys or experiments are undertaken only by governments or on behalf of governments and hence a corporate entity was not involved. But when a country is liable, the location of the accident/damage has to be determined. Which brings in the concept of the boundary of a nation. As of now a territorial boundary of a nation extends into the air also; if you cannot enter the land of any nation, you cannot also enter the air space above the land. However this transgression is monitored only up to the stratosphere boundary because aircrafts now fly only up to that height. The zone between the stratopause and the outer space was not customarily occupied by anybody. If sub orbital flights and hyperplanes of a private entity are going to populate that zone, obviously there is a need to define the territorial boundary beyond stratosphere. There is also need to define the boundary where the Space begins or to clearly demarcate the zone which will be called Space.

Richard Branson went up to the altitude of 83 km as one school considers that as the boundary of Space. However, Jeff Bezos went a few kilometers further till the Karman line. This interface was proposed by a scientist with that name, based on the molecular density of the air as well as the physics and engineering considerations (related to aerodynamic lift versus gravity drop).

Till now all tourist spacecrafts have taken off from the USA and also landed back there. When flights begin to take off from nations with smaller geographical footprint, they may land back in a different nation. It could be with previous arrangement, but yet the issues related to liability will have to be predetermined. Add to this the design variations like recovery of used rocket shell or landing by parachute, etc. and you begin to anticipate legal wrangles.

Many technologies are considered '*double edged swords'*, having a potential to harm as big as to help — like nuclear energy, internet on mobiles, human cloning, pre-natal tests of foetuses and now Artificial Intelligence. Space technology, for sure, was a single-edged tool till recently; however it could develop the other edge if space consumerism turns prolific.

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TIMEKEEPING ON THE MOON

Shaping Lunar Explorations

Meher Wan & Shanay Rab

The establishment of lunar Moon time and its synchronisation with Earth's timekeeping system is critical for efficient space exploration and scientific research.

Image credit: Pixabay

THE Moon, Earth's closest celestial neighbour, has become a focal point of interest for countries around the world due to its potential resources and geopolitical significance. As the human race looks to expand its horizons beyond Earth, understanding the Moon's importance is crucial for space exploration and scientific research. The Moon is a treasure trove of scientific knowledge waiting to be unlocked. Its pristine surface holds clues about the early history of our solar system, as well as Earth's own geological past. By studying lunar rocks and regolith, scientists can gain insights into the Moon's formation, impact history, volcanic activity, and much more.

However, scientific interest is not the only motive for most lunar missions — there are other major attractions including potential economic and strategic ones. One of the Moon's significant attractions is the potential presence of water in permanently shadowed regions at its poles. Water is considered a valuable resource for human space explorations, as it can be used for oxygen production and the generation of rocket fuel through water splitting into hydrogen and oxygen.

Further, the Moon is thought to contain a substantial amount of Helium-3 which is estimated around concentrations of 1.4 to 15 ppb in sunny areas and up to 50 ppb in permanently shadowed regions. It is a rare isotope that could be used as fuel for nuclear fusion reactors. Fusion power has the potential to provide vast amounts of clean and sustainable energy, and the Moon's Helium-3 reserves are of great interest to several countries.

The concept of space resource utilisation, also known as *In-Situ* Resource Utilisation (ISRU), involves extracting and using resources found on celestial bodies like the Moon to sustain human activities on Earth. For countries planning long-term lunar missions or even establishing lunar bases, ISRU could provide essential supplies such as water, oxygen, and building materials reducing reliance on Earth for expensive and logistically challenging shipments on celestial bodies.

The strategic importance of the Moon also stems from its potential to become a future staging point for deeper space exploration, which includes future missions to Mars and beyond. Establishing a permanent human presence on the Moon could enable certain countries to gain valuable experience in living and working in space, preparing them for more ambitious interplanetary missions. The ability to extract and utilise lunar resources could lead to competition between spacefaring nations, mirroring past geopolitical rivalries on Earth.

Growing Interest in Moon

In the 21st century, a flurry of lunar missions have been planned, some even executed, and each promising groundbreaking discoveries.

NASA's Artemis programme spearheads efforts to return humans to the Moon and establish a sustainable presence, targeting the first woman and man of colour on the lunar surface. Several countries and space agencies are coming together to pool their expertise and resources in the Artemis

Image credit: Flickr

programme. NASA will collaborate with commercial and international partners to establish the first long-term presence on the Moon. Utilising the Space Launch System (SLS) and Orion spacecraft, NASA aims to build the Gateway, a lunar outpost fostering international collaboration.

The European Space Agency plans to contribute the European Service Module for Artemis missions. Incidentally, Russia's Luna-25 mission that planned to explore the Moon's South Pole recently ended in failure. China's CNSA eyes the Chang'e-7 mission for comprehensive lunar exploration, including a sample return from the South Pole-Aitken Basin. The Moon's South Pole has not yet been extensively studied. The Indian mission Chandrayaan-3 also holds great importance in exploring the South Pole of the Moon.

Private companies have also joined the lunar race, bringing innovation and entrepreneurial spirit to the table. SpaceX, led by visionary entrepreneur Elon Musk, is actively developing its Starship spacecraft. Intended not only for lunar missions but also for Mars colonisation, Starship is expected to play a pivotal role in NASA's Artemis programme, facilitating lunar landings and potentially transporting astronauts and cargo to lunar bases. Blue Origin, founded by Amazon's Jeff Bezos, is also vying for a slice of the lunar pie. Their Blue Moon lander, equipped with advanced technologies, aims to support human missions and deliver payloads to the lunar surface, contributing to a sustainable lunar presence.

Time on the Moon

However, there is no independent timekeeping for explorations on the Moon. Each lunar mission operates on a unique timeline that is connected to its handlers on Earth. Deep space antennae are employed for this purpose to enable two-way communications while also maintaining onboard clock synchronisation with terrestrial time.

But in the new era of lunar exploration, this mode of operation will not be viable. Precise timekeeping on the Moon is essential for conducting experiments and generating a technical ecosystem as accurate time measurements aid in coordinating lunar exploration missions, calculating launch windows, and managing spacecraft operations. The lunar time serves as a reference for potential human colonisation efforts, helping to regulate life and work schedules on the lunar surface. Ultimately, establishing a standardised time system on the Moon facilitates safer and more organised exploration and scientific endeavours.

Technical challenges in lunar timekeeping include coping with long lunar nights, managing power generation and storage, dealing with communication latency, achieving precise lunar mapping and navigation, adapting to altered human circadian rhythms, mitigating lunar dust, developing autonomous systems, establishing sustainable lunar bases, and utilising lunar resources effectively. These challenges demand innovative solutions such as advanced thermal management, robust power storage, accurate time synchronisation, visual landmark navigation, human physiology studies, dust mitigation techniques, AI-driven autonomous technologies, durable lunar habitats, and resource utilisation for fuel and construction materials.

Addressing these challenges is vital for successful lunar missions and sustainable human presence on the Moon. Space agencies and private companies are continuously working on innovative solutions to overcome these hurdles and unlock the full potential of lunar moon time for scientific research, resource utilisation, and human exploration.

Adapting Coordinated Universal Time (UTC) for lunar time synchronisation is a critical consideration in lunar exploration missions. UTC, based on the Earth's rotation, serves as the standard timekeeping system for most human activities on our planet. However, its use on the Moon presents unique challenges due to the Moon's distinct rotation and orbital characteristics. To ensure effective time synchronisation between Earth and lunar missions, lunar time must be translated into a format compatible with UTC.

One approach is to create a lunar variant of UTC that accounts for the Moon's longer day (lunar day) and night cycle. This could involve adjusting the time scale to match the lunar day, which lasts approximately 29.5 Earth days, and incorporating lunar months in the calendar. Additionally, considering the communication delay between Earth and the Moon, it is crucial to implement reliable timekeeping systems onboard lunar spacecraft and rovers. Autonomous systems that can adapt to lunar time variations and account for the communication latency will be instrumental in smooth mission operations.

On Earth, time is managed with the help of atomic clocks. Similarly, atomic clocks are indispensable in lunar timekeeping due to challenges like long lunar days and nights, communication delays, and accurate navigation. They ensure the success of lunar missions, scientific research, and human habitation on the Moon. These highly precise devices use atomic transitions to measure time in nanoseconds, coordinating lunar activities — scientific experiments, exploration, safe navigation, supporting lunar habitats and deep space missions — and also maintaining synchronisation with Earth for smooth communication. Their accuracy is vital as humanity ventures farther into space, relying on precise timekeeping for interplanetary navigation and communication with Earth. Scientists are planning to install atomic clocks on satellites which will revolve around the Moon in certain orbits.

But it does not end here. To synchronise time on the Moon with Earth, relativistic calculations are needed. Relativity is vital in lunar timekeeping due to space conditions and the Moon's proximity to Earth. Special and general relativity affect time measurement, causing a slight discrepancy between Earth and lunar time. Spacecraft travelling at high speeds experience time dilation due to relative motion, necessitating adjustments for precise timekeeping and synchronisation with Earth-based systems. General relativity, describing gravity's impact on spacetime, leads to gravitational time dilation on the Moon. Clocks on the Moon run faster than on Earth, requiring calibration of atomic clocks on lunar missions.

Image credit: bipm.org

Incorporating these relativistic effects into lunar mission design will ensure accurate timekeeping for successful exploration, research, and future human activities on the Moon.

Diplomacy over Lunar Time

In the realm of international diplomacy, even seemingly mundane matters like deciding the time on the Moon can become subjects of contention and negotiation. As the lunar exploration race gains momentum, the issue of lunar timekeeping has the potential to trigger debates and diplomatic manoeuvres among spacefaring nations.

Control over lunar time could signify a nation's dominance in space exploration. The chosen time standard could offer economic and technological advantages to the country advocating for it, potentially affecting the lunar market. International collaboration may require a consensus on timekeeping for seamless communication and coordination. Disagreements could lead to diplomatic negotiations, impacting future space governance.

As the race for lunar exploration and colonisation intensifies, the need for a unified approach to lunar time zones and timekeeping becomes evident. International space agencies and organisations are engaging in efforts to reach a consensus.

The United Nations Office for Outer Space Affairs (UNOOSA) provides a platform for member states to discuss the issue, while the International Astronomical Union (IAU) could offer recommendations. Meanwhile, the ESA is working with NASA to figure out how to create standards for communications and navigation on the moon.

Research and simulation studies inform decision-making on lunar timekeeping implications. Striking a balance between national interests and international cooperation remains a challenge, but a unified timekeeping standard is crucial for smooth lunar operations, collaboration, and future governance. The Outer Space Treaty of 1967 establishes principles for peaceful and cooperative space exploration among nations. As space assets become critical for national security, discussions on space weaponisation highlight the importance of preserving space as a peaceful domain. Future perspectives in space exploration hold immense promise, with global cooperation being essential for achieving ambitious missions and fostering peaceful interactions.

Role and Initiative of BIPM

The International Bureau of Weights and Measures (BIPM) is an intergovernmental organisation playing a crucial role in deciding the time on the Moon. As the organisation is responsible for maintaining international standards of measurement, including time on Earth, BIPM ensures that accurate and reliable timekeeping methods are used for lunar missions. BIPM is collaborating with space agencies and organisations involved in lunar exploration to establish a standardised timekeeping system that accounts for the unique challenges of the lunar environment.

Even the most perfectly synchronised clocks would quickly acquire a significant offset since a clock on the Moon will not tick at the same rate as one on Earth due to the differing gravitational field. This highlights the need to resolve issues like:

- Should lunar time be established independently, or should it be synchronised with UTC regularly?
- Should the reference time scale be the lunar surface or the orbital atomic clock?
- How can the time on the Moon be measured, converted to UTC, and compared to the time on Earth?

The BIPM was invited to participate in the international forum debating this issue along with the International Astronomical Union, which fixes standard reference frames, in its capacity as the body in charge of realising and disseminating the UTC as well as defining measurement units and reference time scales. By providing expertise in precise time measurement and synchronisation, BIPM in collaboration with the International Telecommunication Union is contributing to seamless communication, coordination, and successful operations on the lunar surface, enabling humanity's continued exploration and habitation of the Moon.

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Himachal Floods
Crisis due to Ignoring Fragile Ecosystems

Gaurav Kumar, Surbhi Vyas and Monika Koul

Image credit: Flickr

DEVASTATING flash floods have wreaked havoc in the Indian Himalayan region this year. Heavy rainfall-induced flash floods and landslides have ravaged the state of Himachal Pradesh, leading to loss of lives and infrastructure. As per reports in the media, around 330 people have till now lost their lives, 12000 houses have been destroyed, and Rs 10,000 crore monetary loss has occurred this monsoon in the state.

This calamity is yet another reminder of previous flooding disasters in the Indian Himalayas — like the Kedarnath (2013) and Chamoli (2021) floods in Uttarakhand and the Amarnath flash floods (2022) in Jammu and Kashmir. The scale of losses every few years indicates that we are not learning from our mistakes.

As per IMD (India Meteorological Department) reports, Himachal Pradesh experienced 1.2°C warmer temperatures

Image credit: Wikimedia Commons

in 2022 compared to the Long Period Average (LPA) for the period 1981-2010 (IMD, 2023). The rainfall pattern indicated an increase in rainfall (20%–59%) in Shimla compared to the 1971-2020 LPA (IMD, 2023). The monsoon rainfall (742 mm) in the state has exceeded the average monsoon rainfall levels (730 mm), suggesting an increase.

The change in weather and anthropogenic interventions are affecting the precipitation dynamics in the state. It is well understood that a high level of rainfall is the primary driver of flooding and landslides in such geographical terrains. The scale of losses is further exacerbated by poor resource management, arbitrary intervention, and injudicious planning.

Experts have cited widespread cutting of hill slopes, vertical cutting of mountains for widening of roads, tunnel blasting, and hydropower projects as some of the major factors responsible for landslides in the region. This is further exacerbated by increase in precipitation and high temperatures. The Department of Science and Technology (DST) and the Government of Himachal Pradesh, in their report, corroborate that the hills are fragile and cutting of these hills by unskilled and non-technical labourers is increasing the problems.

While the loss of human lives and infrastructure are at the core of the disaster, the surrounding environment (plants, animals, and other life forms) cannot be ignored and left out when mitigation measures are planned. This recent event needs to be examined from various perspectives as it has associated social, ecological, economic, and environmental dimensions.

The plant diversity of the region, the ground flora, the herbs and shrubs, and trees play an important role in holding the soil together and prevent erosion due to flash floods. However, extensive construction projects are eroding the floral diversity in the region. Landslides can alter the pathways of water streams, cause forest losses and destabilise slopes which can be a future threat. The loss of endemic biodiversity in mountain areas impacts native populations dependent on mountain resources, and protection of the flora can help in averting future catastrophes.

The current disaster is not unexpected. There have been many warnings from scientists and environmental crusaders. The cutting of mountains, deforestation, the widening of roads, and the construction of motels and hotels have led to rockfalls and landslides. In the absence of forest cover on hill slopes, the stability of soil firmly held by the tree roots is lost.

Terraced cutting of roads leads to minimum environmental damage. Geologists suggest terraced cutting as a better option for road pavement in mountain areas. According to a paper published in *Current Science* (https://www.currentscience.ac.in/Volumes/100/11/1617.pdf), dynamite used for blasting for construction destabilises the mountain slopes and affects the vegetation that would have taken years, or decades to reach

its climax. Besides, vertical cutting of hills is often undertaken for road widening, causing maximum destabilisation of slopes.

The stone walls that were traditionally constructed and meticulously designed for protection are not constructed in the same manner and are often left loose and are thus insufficient to hold rockfalls and landslides. Fragile stones and gravel fall off and cause injuries to people, and a lot of gravel is washed into the rivers during high rainfall, raising the riverbed and enhancing the flood risk.

The demand for more infrastructure and the increasing load of vehicles will keep on worsening as long as population in hilly areas is allowed to grow unchecked. While rising tourism brings in revenues, it is also imperative to apply the limitations of sustainability to this activity. Revenue generation at the cost of the environment and loss of lives has long-term impacts on societies and the environment rendering it vulnerable.

Studies suggest that the unsustainable development of building infrastructures to accommodate tourists and their demands is putting a lot of stress on the fragile hilly terrains. Compared to the year 2008, the year 2021 saw a 54.88% increase in tourist footprint (HP Tourism Department, 2022). As per the 2011 census, the total population of Himachal Pradesh was 68,64,602 individuals, almost half the number of tourists visiting the state (Census, 2011; HP Tourism Department, 2022).

The rise in tourist economy and revenue has led to unabated construction choking water streams, riverbeds, and mountain slopes. This has led to severe losses during the flooding event. Poor urban planning also contributes to the scale of losses.

Learning from tradition and simple style once symbolised Himachal Pradesh. The Kath-Kuni style construction, the traditional architecture of Himachal, built using stone and Deodar wood providing natural insulation and survived natural calamities. However, modern houses use marble, cement and concrete, the blending is done by untrained masons, who earlier made kaccha and wood houses to earn their living. The architects hired by big private hotels have no idea about the topography, hydrology, geology, and geomorphology of the region. Difficulties in procuring stone and timber due to legal restrictions has added to this.

Besides, large hydropower projects are also severely threatening the fragile ecosystem of the Himalayas. Dams built for hydroelectric projects hamper the release of downstream water. And so, experts advocate small hydropower projects which minimise rampant degradation of environment and is a sustainable solution to meet local electricity demands.

Development beyond carrying capacity and high ecological footprint ignoring nature has caused the flooding and landslide disaster in HP. While infrastructure may be rebuilt, clearing forests, and altering rivers for infrastructure can lead to irreversible loss of biodiversity and the natural environment.

The Himalayas are a tectonically active and young mountain range: 45 Million years (Myr) old compared to the Aravali ranges in India (4000 Myr) [Pandit MK. The Himalayas must be protected, *Nature,* 501(283)]. Therefore, Himachal Pradesh requires careful urban planning considering the climate scenarios, precipitation, and geological factors to prevent the scale of losses during natural disasters.

The disaster management policies in India are largely confined to post-disaster measures; the time has come to emphasise long-term pre-disaster planning, which is based on vulnerability assessments, adaptation, and mitigation measures. While Himachal Pradesh has made commendable efforts to conduct sectorial vulnerability assessments and prepare the State Action Plan on Climate Change (SAPCC) for 2021-2030 (Attri et al., 2019; SAPCC-Himachal, 2021), robust implementation of policies on the ground is lacking.

Long-term policies are useful for building resilience. However, flood disaster requires urgent measures. In addition to the long-term policies, short-term plans comprising adaptation and mitigation strategies depending on a case-to-case basis could be useful. It is important to train the local youth and make interdisciplinary teams of qualified and trained people to study the changes at local level and monitor and register the changes occurring in the environment. This data can help in developing ecological models and make predictions of upcoming disasters.

Several measures are taken to prevent disasters in hilly regions. For instance, protection forests are planted for soil and slope stabilisation; wetlands are promoted as they absorb flood waters and act as shock absorbers during floods; geological assessments of soil, slope, and water movement have to be conducted before construction in the hilly areas to minimise the flooding risk. Constructing check dams to reduce the discharge speed would be further beneficial. As also would be increasing the number of weather stations, installing real-time early warning systems, and identification of high-risk areas using advanced flood modelling techniques.

Further, innovative building materials for construction, and a blend of modern and traditional approaches in construction needs to be adopted. Also, traditional crops, cropping methods and horticultural practices that are sustainable and eco-friendly should be adopted and incentivised so that people are not carried away to adopt modern methods that affect environment.

It is pertinent to implement policies robustly on the ground for desired outcomes. Unless we learn from our mistakes and rectify them, another disaster is waiting to happen.

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"One Week, One Lab" Campaign of CSIR-Fourth Paradigm Institute

CSIR-Fourth Paradigm Institute (CSIR-4PI), Bengaluru, a constituent laboratory of CSIR organised this campaign during 10-15 July 2023, which culminated with the Foundation Day celebrations on 15 July 2023. The curtain raiser of the campaign was formally launched on 21 June 2023 with the inauguration of the CSIR centralised Super Computing facility by Dr N Kalaiselvi, DG, CSIR and Secretary, DSIR. This facility will cater to the traditional as well as AI computing computational needs of CSIR laboratories with an enhanced total peak performance of 4.2 Peta-flops. The "One Week, One Lab" brochure and outline of daily events were also released during the curtain raiser.

The campaign was formally inaugurated on 10 July 2023 at CSIR 4PI. Dr Sridevi Jade, Head and Outstanding Scientist, CSIR-4PI, welcomed the gathering. Chief Guest, Dr KS Yajnik, Founder Head, CSIR-4PI (Formerly C-MMACS), inaugurated the event by releasing the CSIR-4PI campaign inaugural video. Prof. Annapurni Subramaniam, Director, Indian Institute of Astrophysics (IIA) and Guest of Eminence released the brochure of day to day detailed agenda of the event. Dr IA Parvez, Chief Scientist and Chairman, "One Week, One Lab" organising committee, briefed the audience about the activities of the week-long programme.

After the inauguration, about 150 school children from several schools participated in the event "Scientist-Student Connect". They were explained, "What is this AI all about" followed by another interesting class on "GNSS and its applications in earth sciences". Students visited state of art infrastructure facilities such as Cyber security testbed, High-Performance Computing (CHAMP) facility and Greenhouse Gases (GHG) data acquisition. The first day's activities concluded with a keynote address by Dr Narahari Shastry, Director, CSIR-NEIST, Jorhat.

Day 2 event "College Youth Interaction" was inaugurated by Chief Guest Dr Shastry with an inspiring lecture on the importance of students and their upcoming role in shaping the future of cutting-edge technology in India. Dr Jade gave a presidential address to the college students from the Karnataka state and emphasised on human behaviour and the authenticity of data information flowing on social media. The event started with a brief introduction of CSIR-4PI activities through a video followed by a presentation on High Performance Computing (HPC) activities and the application of HPC in the modelling and simulation of extreme weather events across India.

A resource person from Advanced Micro Device (AMD) India Pvt. Ltd conducted a workshop on "Introduction to Compiler Optimisation in AOCC" and AMD Optimise CPU libraries". After the workshop, Dr Anilkumar V, Chief Scientist, CSIR-4PI, interacted with students to make them aware of Intellectual Property Rights as part of the ongoing National Intellectual Property festival. The students visited CHAMP facility, cyber security R&D Lab and participated in the demonstration of GHG data acquisition. Day 2 concluded with a keynote address by Dr Parvez and a feedback session from the students about the daylong event.

Day 3 was held at Karnataka State Natural Disaster Monitoring Centre (KSNDMC), Yelahanka, Bengaluru, on 12 July 2023. Dr Jade chaired the meeting and gave the welcome address. Shri Karee Gowda, IAS, Director, KSNDMC Co-Chaired the meeting and Dr Sridevi Annapurna Singh, Director, CFTRI, Mysuru, addressed the gathering as the Chief Guest. This Day was dedicated to interaction with different stakeholders from Karnataka State on various

R&D activities and technologies of CSIR 4PI relevant to the State. Experts from different government agencies and academic institutes presented ongoing and future possible collaborations. In the afternoon session of the meeting, theme-based round table discussions in areas such as natural disaster forecasting and management, hydrology and water management, geospatial crop monitoring and smart agro-technologies, etc. were conducted followed by theme-wise recommendations, possible areas of new collaborations and formulation of MoUs in the concluding section of the meeting.

Day 4 was dedicated to boosting the collaboration between Industry, Academia and R&D. The event was inaugurated on 13 July 2023 by Chief Guest, Dr VS Prasad, Head of National Centre of Medium Range Weather Forecasting (MoES, Govt of India). Guest of Honour, Prof. RV Ravikrishna, IISc, Bengaluru, delivered the keynote lecture on 'How to Foster a Strong Industry-Academia Connect'. Dr Jade presided over the function and emphasised the need for collaboration among scientists, academia and industry for the benefit of common people of various sectors. Dr KC Gouda, Sr Principal Scientist and convener of this event outlined the day-long programme which mainly aimed at stimulating trans-disciplinary discussions between scientists, scholars, academicians and industry managers. Dr Manish Modani, Principal Solution Architect at NVIDIA, delivered another interesting talk from the Industry, where he presented the application of modern computing in different sectorial applications. The session also witnessed the signing of MoU with NCMRWF and NIT-K Surathkal.

In the technical sessions, several distinguished speakers presented their case studies and success stories on applied science & engineering research and potential for industry collaborations. Representatives from the MSME and start-ups i.e. Ranjita Encons, Cropin, Armtronix, Medvise Futurekare, Srava Labs, Research Realm, Radio2pir, Cognizant, etc. presented their work and actively interacted with scientists, scholars from different organisations, and academicians from various higher educational institutes. Karthikeyan, CSIR-NAL and coordinator of DSIR-PRISM presented the funding opportunities for the innovators. This was followed by a panel discussion moderated by Dr Parvez, and the discussion concluded with suggestions to create a synergy between research labs, industry and academia for the betterment of society.

On Day 5 (14 July 2023), Science Outreach and Road Show event was held at colleges in Bengaluru. Dr Parvez addressed the gathering and explained the programme. Dr KC Gouda presented the idea of interdisciplinary collaboration with colleges. The Principal, all faculty members and students appreciated the science outreach and roadshow programme. They also spoke about how their students benefited from the MoU with CSIR-4PI on collaborative research. Dr Anil gave a talk on Intellectual Property and also discussed the advanced cybersecurity research work at CSIR-4PI. Other scientists and research scholars demonstrated the research technologies of CSIR-4PI at the event.

Day 6 event was dedicated to Farmer-Student-Scientist interaction to create awareness on region-specific smart agro-technologies at CSIR-4PI among students and the farming community, on 15 July 2023 at CSIR 4PI. Dr Jade chaired the meeting and welcomed the gathering. Shri Mahendra Kumar Gupta, Joint Secretary (Admin), CSIR, was the Chief Guest of the event and he addressed the farmers, agriculture students and the guests. Dr Mahendra P Darokar, Chief Scientist, CSIR, Head Quarter, was the Guest of Honour and gave introductory remarks related to CSIR's contribution, particularly in the farming and agriculture sectors. Shri Prabhudev, a farmer from Hosahalli, Vijayanagar District, Karnataka, gave feedback on R&D works carried out at his paddy field by the CSIR-4PI team and shared the experience of realisation of improved yield in his paddy field following farming practice. An interactive session of Farmer-Student-Scientist on critical issues and challenges in the farming environment was also carried out. This was followed by the demonstration of hand-held instruments for agricultural field measurements for the participants of the programme.

In the afternoon, the "One Week, One Lab" programme was concluded during the CSIR-4PI 35th Foundation Day celebrations. Prof. KK Aggarwal, Former Chairman, National Board Accreditation, gave the Foundation Day talk on 'Importance of data and increasing relevance of the Institute'. Prior to that, a glimpse of the day-wise activities was presented in the form of a video to formally conclude the programme.

The culmination of the day's event was the award ceremony where scientific and non-scientist staff of CSIR 4PI were recognised for their contribution in building up the organisation.

CSIR-CRRI Celebrates "One Week, One Lab"

CSIR-Central Road Research Institute (CRRI), New Delhi, dedicated its "One Week, One Lab" programme from 16-22 July 2023 to honouring their groundbreaking accomplishments and fostering collaborations in the road construction and transportation sector across the country.

The curtain raiser on 16 July 2023 set the theme as "Waste to Wealth" for sustainable road construction in India. Esteemed guests, Dr VK Saraswat, Member NITI Aayog & Chancellor, JNU, and Prof. PK Sikdar, Chairman RC and President ICT, graced the occasion as Chief Guest and Guest of Honour, respectively. Notably, they also visited the Steel Slag lab during their visit. The event witnessed the release of the Hindi magazine "सड़क शोधपत्र संकलन वर्ष *2023*" (Road Research Journal Collection 2023) and the CSIR-CRRI "One Week, One Lab" memento by the esteemed guests. Engaging presentations from CRRI, Government, Academia, and Industry took place, focusing on the utilisation of various waste materials in road construction. The day concluded with a panel discussion on the way forward and felicitations to all speakers and the Chairman by Director CSIR-CRRI.

Day 2 witnessed Dr Jitendra Singh, Minister of State (Independent Charge) for the Ministry of Science and Technology and Vice President CSIR addressing and launching the Steel Slag movies. He also launched an Online Road Safety game for school children developed by CSIR-CRRI along with industry partner Chipsoft Solutions Pvt. Ltd, promoting safe and sustainable transport concepts. Sh. Rajashekhar N, IPS, DIG Modernisation, BPR&D, Ministry of Home Affairs graced the occasion as a Chief Guest and Ms Rajni Gandhi, Founder and Secretary of TRAX Road Safety NGO as a Guest of Honour. The guests released Hindi Patrika *Sadak Darpan*, issues 23 & 24. Over 150 students from various schools and engineering colleges participated and witnessed the state of art facilities in CSIR-CRRI. A thought-provoking lecture on

Intellectual Property Rights was also delivered by Dr Bhanu, Senior Principal Scientist at IPU CSIR during Azadi Ka Amrit Mahotsav celebrations as "Rashtriya Boudhik Sampada Mahotsav" (National Intellectual Property Festival).

The Industry Meet had Ms Ruchika Chaudhary Govil, Additional Secretary Ministry of Steel, as the Chief Guest, and Shri Mahendra Kumar Gupta (IRPS), Joint Secretary, CSIR, as the Guest of Honour. Their addresses facilitated fruitful discussions on bridging the gap between research and industry practices. More than 100 industry representatives actively participated, fostering collaborations between CRRI, the road construction industry, and the Steel Industry. The sessions were chaired by Shri RK Pandey, Advisor, MORTH India, Sh. IK Pateriya, Director (Technical), NRIDA, Dr LP Singh, Director General, NCCBM and Sh. SK Nirmal, Secretary-General IRC. An impactful address by Hon'ble MoS, Shri Faggan Singh Kulaste, Minister of State, Govt of India, on the future of steel research and its impact on road infrastructure development added significance to the event. During the industry meet, CSIR-CRRI Scientists presented their latest inventions, technologies & possible areas for collaboration and Industries gave presentations of their latest products/services in the areas of transportation sector.

During the event following Project Agreement and Technology Transfer Agreements were signed:

i) A Technology Transfer Agreement signed on 18 July 2023 with Somani Ecobuild Products LLP for the development of cementitious material for stabilisation of the Sub-Base & Base course in Flexible Pavement.

ii) A Project Based Agreement signed on 18 July 2023 with Arjas Steel Private Limited for the Development of customised steel slag valorisation Technology for LD/ BOF steel slag for Arjas Steel Private Limited, Tadipatri

Plant, Andhra Pradesh for conversion of BOF Steel Slag as Road Making Aggregates.

Day 4's Young Researchers Conclave witnessed Shri Chetan Prakash Jain, IPRS, CMD, CEL & JS, Finance (FA), CSIR, as the Chief Guest, and CMDRe Amit Rastogi, CMD of NRDC (National IP Festival), as the Guest of Honour in the inaugural session. The inaugural address by Shri Chetan Prakash Jain highlighted the significance of various wings of DSIR, CSIR, NRDC and CEL and also emphasised the role of young researchers. Also included a lecture on "Technology development conundrum Researcher's Perspective" as part of the CSIR-CRRI National Intellectual Property Conclave. He covered the way forward for technology development and the approach towards industrial research and threw light on how to protect innovation and invention through Intellectual Property Rights and the prevailing IP trends across the country. It was followed by the inauguration of a Poster Presentation, Trans Tech Blitz and Virtual Labs and interaction with participants by Shri Chetan Prakash Jain, CMDRe Amit Rastogi and Prof. Manoranjan Parida, Director, CSIR-CRRI.

The second session involved a keynote lecture and question-answer session by Dr Viswajanani Sattigeri, Outstanding Scientist and Head, TKDL-CSIR, the Chief Guest of the session on CSIR-CRRI National Intellectual Property Conclave, on the topic "Intellectual Property — What, Why and How?" She covered the gamut of concepts of IP in the global as well as Indian context. The concluding session was chaired by Dr Ranjana Aggarwal, Director, CSIR-NIScPR.

Day 5 workshop on Engaging with State Government at Bhubaneswar, Odisha, featured Shri Vir Vikram Yadav, IAS, Principal Secretary, Works Department, Government of Odisha as the Chief Guest. He enlightened the gathering with his thoughts and inaugurated the exhibition. The discussions during the workshop emphasised collaborative efforts for transportation advancements, research-to-implementation, and bridging gaps. The major theme centred on road asset management and bridge management systems for sustainable infrastructure development. Engaging discussions with government officials, experts and researchers on road safety and innovative technologies were held. The Young Researchers Meet provided an invaluable platform for student engagement and knowledge sharing.

Day 6 at IIT Hyderabad's KRB Auditorium focused on Next Generation Transport. Dr N Kalaiselvi, DG, CSIR, & Secretary DSIR, served as the Chief Guest, along with Shri Jayesh Ranjan, IAS, Principal Secretary, Ministry of IT, Telangana, as the Guest of Honour. CSIR-CBRI & IIT Hyderabad also signed an MoU. The session delved into the practical applications of Artificial Intelligence (AI) and Machine Learning (ML) in road safety, driver behaviour, sustainable pavement using recycled materials, and innovative technologies in road construction and data analytics.

The final day hosted Shri K Moses Chalai, IAS, Secretary, NEC, as the Chief Guest, along with Shri PKH Singh, VSM, ADG BRO (East), and Prof. Parameswar K Iyer, Officiating Director IIT Guwahati, as the Guest of Honour. The focus was on transportation and infrastructure development in the North Eastern region of the country. Experts, government officials, and CRRI scientists engaged in discussions and valuable contributions. An MoU was signed between IIT Guwahati and CSIR-CRRI, fostering research collaboration and student exchange. The event also included a student session with NIT Meghalaya students, allowing a glimpse of their perspectives on road development in the region.

CSIR-CRRI's weeklong celebration showcased remarkable achievements, engaged with the state, promoted industry collaboration, encouraged student engagement, looked at the North East region and addressed vital road construction and transportation issues. These efforts are expected to significantly contribute to India's sustainable infrastructure development and road safety objectives.

CSIR–CECRI's "One Week, One Lab" Programme

CSIR-CECRI (CSIR-Central Electrochemical Research Institute), Tamil Nadu, conducted the "One Week, One Lab" programme during 24-28 July 2023.

The curtain raiser of "One Week, One Lab" was held on 24 July 2023 by Dr Debashish Bhattacharjee, Vice President, Technology & R&D, Tata Steel Ltd, Kolkata. Shri DM Raipure, Chairman Tungabhadra Board, Karnataka, and Dr Kartik Kumar, R&D Director, Saint Gobain India Pvt. Ltd, Chennai, were the Guests of Honour. A video on "CECRI's R&D Glimpses" and "CECRI's Technology Capsule", were released.

"CECRI-Industry Connect" was organised in which delegates from various industries actively took part in the deliberations and provided their feedback on the ongoing collaborations and future requirements to strengthen their relationship with CECRI. The event witnessed the handing over of two prototypes of the "Piezoelectric Dynamic Pressure Sensor" developed by CECRI to ISRO's IPRC. A

new agreement was signed for contract R&D on atmospheric corrosion testing with Saint Gobain India Pvt. Ltd, India. Day-1 also had "CECRI-Alumni Connect" event through a hybrid mode in which alumni of BTech, PhD and TWAS Fellows of CSIR-CECRI interacted with the present students.

Day-2, 25 July 2023, marked CSIR-CECRI's 76th Foundation Day. On this occasion, Dr N Kalaiselvi, Director General, CSIR & Secretary, DSIR was the Chief Guest. In her address, Dr N Kalaiselvi, DG, CSIR highlighted the pivotal role of electrochemistry and electrochemical processes in addressing energy and environmental issues. Shri Bhupinder Singh Bhalla, IAS, Secretary, Ministry of New and Renewable Energy (MNRE) delivered the 76th Foundation Day Lecture. In his address, Shri Bhalla stressed the importance of large-scale processes for green hydrogen production and mentioned CSIR-CECRI's contributions to MNRE schemes. The Directors of sister labs, Dr KJ Sreeram, Director, CSIR-CLRI and Dr N Anandavalli, Director, CSIR-SERC, attended the event.

The following new experimental facilities were inaugurated during these two days:

1. Molten Salt Metallurgy Facility
2. ϒ-MnO_2 Pilot Plant
3. Green Hydrogen Laboratory (HyLab)
4. Electroplating Facility
5. Climate Action Building (CAB)

A product on the commercialisation of CSIR-CECRI's Technology on "3D Printable Polymer Filaments" by the licensee M/s. Monotech Systems Limited, Chennai, was also released.

CECRI-Industry Connect on Corrosion Mitigation was held on Day-2. As a part of CECRI-Social Connect, a Students Rally was planned on the same day to create awareness among the general public on CECRI's technological contributions, Intellectual Property Rights (IPR) and "One Week, One Lab" activities. The rally was inaugurated by Sivaganga District Collector, Smt. Asha Ajith, IAS.

"Padma Shri" Prof. Anil K Gupta, Founder of Honey Bee Network and National Innovation Foundation, Ahmedabad as the Chief Guest addressed the students on the third day under CECRI-Students Connect. A lecture on IPR was delivered by Dr T Pavan Kumar, Senior Scientist, CSIR-IMMT, Bhubaneswar. Day-3 also had a programme on Do-it-yourself (DIY) kit demonstration on various topics including batteries, sensors, etc. by school students.

The events of Day-4 were parallelly conducted at Chennai and Karaikudi. The Energy Technology Meet was held at CECRI Chennai Unit located in the CSIR Madras Complex at Taramani, Chennai. The meet was inaugurated by Dr R Venkatadhri, Chief Innovation and Digital Officer, Tata Chemicals, Mumbai. Prof. AK Shukla, former Professor, Indian Institute of Science, Bengaluru and former Director of CSIR-CECRI, Karaikudi, and Dr R Madhan, Director, IGSTC, New Delhi, were the Guests of Honour. The event included two sessions: "Hydrogen Energy: Generation, Storage, and Utilisation" and "Battery Technologies for e-Mobility" with lectures by industrial delegates and CECRI Scientists. A panel discussion on "Driving India's Green Future: Exploring the Potential of EV Industries, Li-ion Batteries, and Fuel Cells" was also held.

On Day-4, at CSIR-CECRI, Karaikudi, Hands-on Training on Patent Writing was provided by Dr T Pavan Kumar, Sr Scientist, CSIR-IMMT, Bhubaneshwar.

CSIR-CECRI conducted Electroplaters' Meet on Day-5 at Madurai to showcase the developments in electroplating to entrepreneurs of electroplaters of Madurai. The event was inaugurated by Dr Rajeev Mehta, Scientist-H, Inter-University Accelerator Centre (IUAC), New Delhi. Shri P Natarajan, President, Electroplaters & Metal Finishers Association, Madurai, and Smt. R Uma Chandrika, Assistant Director, MSME, Madurai were the Guest of Honour. A live demonstration of electroplating was conducted for college students.

The Valedictory Function of CSIR-CECRI's "One Week, One Lab" was held on Day-5 at CSIR–CECRI, Karaikudi. Dr GA Pathanjali, Managing Director, High Energy Batteries (India) Ltd, Mathur and Dr Rajeev Metha, IUAC, New Delhi, were the guests to provide the valedictory address. Dr K Ramesha, Director, CSIR-CECRI presided over the function and acknowledged the entire CECRI fraternity for their support in convening the events in a grand manner.

CSIR-CFTRI "Celebrates One Week, One Lab"

CSIR-Central Food Technological Research Institute (CFTRI), Mysuru, celebrated the "One Week, One Lab" programme during 3-7 July 2023. The Curtain raiser event of CFTRI was attended by Dr N Kalaiselvi, DG, CSIR and Secretary, DSIR, on 20 June 2023.

On 3 July 2023, the programme was inaugurated by His Highness Shri Yaduveer KC Wadiyar, 27th Head & Custodian of the Erstwhile Kingdom of Mysuru. Mr Ashok Dalwai, IAS, CEO, NRAA & Chairman, Empowered Body of Doubling Farmers' Income; Dr V Prakash, Distinguished Scientist of CSIR and Dr SR Bhowmik, Former Director of CFTRI were Guests Of Eminence.

The day 2 was inaugurated by Chief Guest Dr Soumya Swaminathan, Former Chief Scientist of WHO, and Dr MV Rao, IAS, Chairperson, West Bengal Electricity Regulatory Commission, was Guest of Eminence.

On the third day of the event, two new technologies were released, and a poster session was also inaugurated by Dr Chindi Vasidevappa, Former VC, NIFTEm-H. Dr Chindi also distributed the prizes of CSIR JIGYASA competitions.

During the programme, a walkathon was organised by CFTRI in association with FSSAI India under the theme "Eat

Right Millet Walkathon" to promote awareness about millets during the International Year of Millets 2023. Earlier on that day, The Millet Walkathon was inaugurated by Dr Sridevi Annapurna Singh, along with other esteemed dignitaries. The Marathon saw the enthusiastic participation of over 500 individuals, covering a distance of nearly 3 km.

The programme was concluded on 7 July 2023 and was attended by Dr KV Rajendra IAS, DC, Mysuru; Ms Shilpi Agarwal, DRM, Mysuru, SWR & Dr G Narahari Sastry, Director CSIR-NEIST, Jorhat.

SAMAR KUMAR BAGCHI

TRAILBLAZER IN SCIENCE POPULARISATION PASSES AWAY

Dhrubajyoti Chattopadhyay

Samar Bagchi as a young Curator at BITM, Kolkata

THE world of science popularisation mourns the loss of one of its most illustrious pioneers, Samar Bagchi, who departed in the early morning on the 14th of July 2023. With a career spanning over several decades, Samar Bagchi was a remarkable figure whose passion for bringing science to the masses was truly unparalleled.

His journey began in 1962 when he assumed the role of curator at the Birla Industrial and Technological Museum, which was then under the aegis of the Council of Scientific and Industrial Research (CSIR). Later, it moved into the fold of the National Council of Science Museums (NCSM). He went on to become the Director of this pioneer museum, until his retirement in 1991.

Over the years, his dedication and commitment to the cause of science education and science popularisation made him popular among students. With boundless energy and zeal, he traversed every corner of the country, inspiring countless individuals, young and old, with the wonders of science. Despite facing the challenges brought on by age and illness, including a valiant battle with cancer, Samar Bagchi remained undeterred, continuing his mission with unwavering determination. As we reflect on his extraordinary life and legacy, we remember Samar Bagchi as a beacon of knowledge, whose infectious enthusiasm for science ignited the minds of generations and will continue to shine brightly in the hearts of those entire he touched.

He was born in 1933 in Purnea, Bihar. Samar Bagchi's early life was deeply influenced by his upbringing in a joint family, surrounded by six brothers and one sister. His father was a Health Officer under the District Board, leading to frequent transfers that exposed young Samar to various locales, specially the hill regions of Bihar.

At the tender age of five, he moved with his family to Dumka, a captivating district headquarters in the Santhal Parganas region, now part of Jharkhand, where he started his initial foray into education. However, fate had more transitions in store for the young scholar, as his father's job eventually led the family to Munger, Bihar. He completed his matriculation from Munger. However, tragically he lost his father and the family had to shift in Kolkata. Yet, Samar Bagchi's determination to pursue knowledge remained undeterred.

In Kolkata, he took admission in Scottish Church College for pursuing his BSc. The years spent at the Scottish Church College proved to be formative for him, as he not only acquired valuable knowledge in science but also honed his passion for hands-on learning and experimental teaching, which he had embraced under the guidance of remarkable teachers like Prof DP Ray Chaudhuri. Another teacher Bipin Babu of the same College left an indelible mark on young Bagchi, instilling in him a deep appreciation and a love for poetry in both English and Bengali.

After completing his BSc from Scottish Church College, he enrolled at the School of Mines in Dhanbad, in 1953. He completed his graduation in mining engineering in 1957. At that time to become eligible for managerial roles, aspiring candidates had to undergo rigorous examinations for the 2nd Class and 1st Class Mine Manager's Certificates. After two years of training in a mine, he successfully obtained his 2nd Class Mine Manager's Certificate and took up the position at a colliery in the Mokama Coalfield, situated between Dhanbad and Asansol. His dedication and commitment to work shone brightly as he served in this capacity for two years before achieving the prestigious 1st Class Mine Manager's Certificate.

These early experiences in the mining industry not only shaped Samar Bagchi's professional trajectory but also

Mr Bagchi in his residence at Kolkata

strengthened his belief in the importance of practical learning and its application in the field of science. Little did he know that these early chapters of his life were just the beginning of an illustrious journey that would see him become a trailblazer in science popularisation, touching countless lives and leaving an enduring legacy in the realm of scientific education in India.

After a successful stint in the mining industry, Samar Bagchi's life took an unexpected turn when he stumbled upon an advertisement in the newspaper for the position of Curator (Mining and Metallurgy) at the Birla Industrial and Technological Museum (BITM) in Calcutta. At that time, he had little knowledge of what a job at a science museum entailed, but something about the opportunity piqued his interest, and he decided to apply for the position.

The decision to leave behind the lucrative job in the coal mine was not an easy one for any person. During his college days at the School of Mines, he had suffered a slip disc, likely due to pole vaulting, which necessitated a surgical procedure in 1959. This injury made underground work increasingly challenging for him, and he sought a career change that would be more accommodating to his physical well-being.

Despite the salary offered at BITM being less than half of what he earned in the mines, and the reduction in privileges, Samar Bagchi's passion for science and his desire to explore the realm of science popularisation motivated him to pursue the opportunity. With determination and a sense of purpose, he applied for the position, ultimately securing the job. Little did Samar know that this career move would prove to be a pivotal moment in his life, setting him on a path where he would contribute significantly to the field of science communication and popularisation. His tenure at BITM would mark the beginning of a remarkable journey dedicated to igniting the spark of scientific curiosity and knowledge in the hearts of countless individuals, leaving an indelible impact on the world of science education in India.

When Mr Bagchi joined BITM, he had no prior experience in science museums. However, that did not deter him from taking on the challenge of developing a Mining Gallery, which opened its doors in 1964. The exhibit not only showcased the significance of mining but also set a precedent for future thematic galleries at BITM. In 1978, when a new museum building emerged on the BITM campus within its basement, the iconic Mock-up Coal Mine was designed, simulating the experience of a real coal mine. It became a major attraction for visitors, providing them with a unique understanding of the coal mining industry. To this day, it stands as a testament to Mr Bagchi's innovative approach to exhibit design.

Mr Bagchi's commitment to fostering education extended beyond the conventional. The "Animalorium" project, inspired by writer Narayan Sanyal, aimed to engage visitors with live demonstrations of snakes and lizards, promoting an understanding of biodiversity. Additionally, the Aquarium, Aviary, and Pet Club were introduced to offer hands-on learning experiences to the public. Though some activities faced challenges due to objections from animal lovers, they marked a significant step towards promoting environmental awareness.

After retirement he fully engaged in science popularisation, here seen in an interactive session in JBNSTS, Kolkata

Under Mr Bagchi's guidance, BITM spearheaded several groundbreaking educational programmes. The Mobile Science Exhibition brought science outreach to schools and villages, while the Science Demonstration Lecture series covered essential scientific concepts. The School Loan Service Programme, where scientific kits were loaned to schools, and the Creative Ability Centre provided platforms for fostering talent and curiosity among students.

Mr Bagchi's crowning achievement was the creation of the exhibition "India: A Festival of Science". This exhibition showcased India's contributions to science, particularly focusing on linguistics and music. It was taken to the United States and toured several cities, earning accolades and appreciation for its innovative approach.

Mr Bagchi's vision transcended the confines of the museum. In collaboration with professionals and social activists, he spearheaded socio-economic development projects in Purulia, uplifting tribal communities through training programmes in agriculture, iron-making, and more. This endeavor showcased how a science museum could extend its influence far beyond its walls, contributing to the betterment of society.

Samar Bagchi's tenure at BITM stands as a testament to the power of innovation and dedication in transforming an institution. From captivating galleries to impactful educational programmes and socio-economic initiatives, Mr Bagchi redefined the role of a science museum in the community. His pioneering efforts continue to resonate, encouraging the next generation of curators and education assistants to explore the uncharted territories of science communication and societal development.

Samar Kumar Bagchi dedicated his retired life to science popularisation. Although never a teacher by profession, Bagchi embraced the challenge of promoting science education and tirelessly working to make science education accessible and engaging to all, regardless of limited resources.

Bagchi's approach to science teaching was innovative and practical, emphasising hands-on experiments with "no-cost, low-cost materials". He firmly believed in the importance of understanding science as a means to comprehend the world better. His teaching methods are rooted in humanism, drawing inspiration from great thinkers like Rabindranath Tagore, Mahatma Gandhi, and Acharya Prafulla Chandra Ray, as well as the principles of Marxism.

Since his retirement in 1991, Bagchi conducted over 350 workshops for science teachers across India, spanning from Kashmir to Kerala and Gujarat to the Andaman and Nicobar Islands. These workshops aimed to equip teachers with effective and engaging techniques to teach science in classrooms with limited resources. Bagchi was known to start these workshops by testing the teachers' knowledge with simple experiments, often revealing the need for practical and engaging science education.

Despite age and health challenges, Bagchi's relentless commitment to science popularisation remained unwavering. He continued to visit schools and record lessons, demonstrating physics experiments that captivated his audiences and promoted curiosity-driven learning. He believed that science is best understood through practical demonstrations and experiments that spark students' interest in the subject.

Bagchi's passion for science and education extended beyond the classroom. He was an environmentalist and social activist, advocating for sustainable development and responsible stewardship of the planet. His work with Khelaghar and other schools showcased his dedication to empowering marginalised communities, especially young girls from the Santhal tribe, with education and knowledge. He emphasised that no monetary package can compensate for the displacement of tribal communities caused by harmful developmental projects.

The impact of Bagchi's contributions to science popularisation can be seen in his leadership at BITM, where he was instrumental in creating exhibitions that showcased India's scientific heritage. He proudly added sections on contributions of Indian music and linguistics to science, highlighting the harmony between different disciplines.

Bagchi's vision for science education went beyond conventional notions of progress and consumerism. He believed that science should work in harmony with nature and not be tied down to capitalist interests. Instead, he advocated a higher culture built on knowledge and science, drawing from historical examples like the Islamic Renaissance of the 9th century.

In the midst of the challenges posed by the rapidly advancing technology and automation, Bagchi urged society to retain faith in humanity. By drawing inspiration from Tagore's teachings, he encouraged individuals to remain committed to social progress and the welfare of all.

Samar Kumar Bagchi left an indelible mark on the hearts and minds of those he touched.

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UNFOLDING THE STORY OF THE BETEL NUT

Parul R Sheth

THIS story is about the tiny little betel nut, the fruit of *Areca catechu*, a type of palm tree, colloquially known as 'supari'. The nut has been used widely for centuries. The deep red smile seen on the faces of people from Asia and the Pacific Islands comes from the chewing of betel nut.

According to the World Health Organization (WHO), around 600 million people worldwide consume some form of betel nut. It is used by almost a tenth of the world's population including adolescents who perceive the nut to be harmless. It is easily available commercially; there is no restriction on selling it.

In India, areca nut plantations surround the coasts of Karnataka, Kerala, Tamil Nadu, West Bengal, Assam and Maharashtra. Munching of betel nut has remained a part of Indian culture and also in the whole of Southeast Asia. Chewing betel nut is a popular cultural activity in Asian countries including Guam, Maldives, Bhutan, Nepal, Sri Lanka, Bangladesh, Myanmar, China, Laos, Thailand, Philippines, Cambodia and Vietnam. In Vietnam, areca nut and betel leaf are important symbols of love and marriage. In China and Sri Lanka, areca nuts are chewed along with 'paan', also known as betel quid. The combination of areca nut and betel quid is consumed by about 8 per cent of the world's population.

Surprisingly, the addicting nature of betel nut chewing has been camouflaged and is not talked about. Betel nut is one of the most popular psychoactive substances in the world that ranks fourth after nicotine, alcohol and caffeine. There are not many anti-betel nut reports and yet the medical fraternity has pointed the ill effects of long-term consumption of betel nut. It is time to review, evaluate and weigh the pros and cons of betel nut, which has been around for centuries.

Indian Chronicles

The use of betel nut can be traced back to 2500 years. The Indian history of betel nut dates back to the pre-Vedic period. Ancient Sanskrit scriptures too make a mention of the nut. Betel nut chewing is a habit passed down through generations.

There was a custom amongst the Royals to chew betel nut with betel leaf. They offered the beeda to strike an alliance. Guests were offered beeda after meals. And the tradition is still prevalent in recent times. People chew supari with paan, because of the breath-freshening and relaxant properties of the nut. The nut is commonly used in Indian religious and wedding ceremonies too. In Hindu religion, supari is considered pure and a fruit of "divine origin" and is hence used in every ritual, be it a wedding or puja.

Supari is mostly used as 'mukhwas' or mouth freshener, which is eaten after meals. 'Paanwalas', who sell paan or betel quid are common sights in narrow lanes of Indian villages, towns and cities. Every state in India has some tradition regarding the betel nut use.

It has many colloquial names. It is known as 'kwai' and 'gue' in Meghalaya. In Manipur and Mizoram, it is 'kua' and 'kuhva'. In Assam and Nagaland people call it 'tamul'.

India has several varieties of betel nut preparations — bura tamul, tambul, chali or kottapak, parcha, kalipak, neetadaka, nayampak, nuli, chikani, etc. In Assam, tamul is prepared by preserving ripe fresh nuts for three to four months under the bark from the betel tree, cow dung and soil. This results in a moist preparation of betel nut that is easy to chew. The tradition is to offer paan and tamul to guests after tea or meals.

How can we forget the 'paan ka dabba' used by our ancestors? Ingredients of paan are stored in a 'paandan', which consists of an ornate box available in various shapes and sizes. A special nutcracker to shred supari into slivers, is a must in the paandan. The paan container made out of metal or wood, comes in various sizes and shapes.

The Omnipresent Nut

What is paan or beeda? Although sharing the same name, betel nut and betel leaf (paan) come from completely different plants. The heart-shaped leaf comes from *Piper betle,* a perennial creeper (vine) of the family Piperaceae, which includes black pepper and Kava. On the other hand, betel nut is the seed of the fruit of areca palm — *Areca catechu*. The areca palm cultivated in India has a trunk reaching 12-15 metres and is around 45 centimetres thick. Six to nine large pinnate leaves very similar to a palm tree, top the trunk. The fruit of this plant has a hard grey, brown seed within its fibrous rind.

Areca nut plant can protect the environment. Plates made out of areca nuts are an environmentally friendly alternative to plastic plates. These are made from fallen areca leaves. The plates are biodegradable, lightweight and easily stackable and can be used to serve both hot and cold food.

The seed is used either fresh, dried boiled, baked, roasted or cured. The fresh ('kachha' supari) or roasted ('pakka' supari) is sliced or made into pieces and is rolled into a betel leaf — betel quid or paan that is layered with a dash of slaked lime — calcium hydroxide ('chuna') and catechu ('kattha'), which gives out red colour on chewing. Catechu is an extract of acacia trees. In fact, betel nuts also contain catechu. People consume paan with or without tobacco, cloves, cardamom, nutmeg, aniseed, 'gulkand' and other ingredients to enhance its flavour. Chewing of paan with supari results in a flow of brick-red saliva, which can temporarily dye the mouth, lips and gums orange-brown and stain teeth.

Most of the packaged betel nut products are manufactured in India and Pakistan and are exported worldwide. The most common commercial preparations are 'gutka' and 'pan masala'. Gutka contains powdered tobacco with betel nut, slaked lime, catechu and condiments. 'Pan masala' contains the same mix, with or without tobacco. Areca nut is also used in 'mawa' with tobacco and slaked lime marketed in colourful tiny sachets with added sweeteners and flavours.

Composition and Effects

Betel nut contains carbohydrates, fats, proteins, fibre, polyphenols — flavonols and tannins, minerals and mainly alkaloids. It has several alkaloids belonging to the pyridine group, the most important being arecoline. The others are arecaidine, guvacine and isoguvacine. The seed also contains condensed tannins (procyanidins) known as areca-tannins, which are carcinogenic.

Betel nut with or without betel quid has not been tested in clinical trials and therefore evidence of its health benefits or ill effects is restricted. Yet there are certain positive

evidence-based reports regarding its benefits. Arecoline in betel nut is a mild Central Nervous System (CNS) stimulant that raises the respiration rate. The psychoactive properties of the nut help treat schizophrenia — a mental disorder. The other beneficial effects of the nut include its anti-inflammatory and wound-healing properties. In addition, betel nut is used as a digestive aid and helps in the treatment of roundworms and tapeworms, glaucoma and anaemia.

Alternate therapeutic doctrines such as Ayurveda have included betel nut in their list of healing medicines. Traditional Chinese medicines too use betel nut preparations as a cure for headache, stomachache, fever, rheumatism, venereal diseases and other ailments.

In spite of all the reported health benefits of betel nut, more clinical research is needed for long-term consumption of betel nut in any form. The lacuna is the lack of follow-up studies.

To Consume Or...

The global areca nut market is growing at a rate of 4.50% CAGR (Compound Annual Growth Rate) during the forecast period of 2023-2028 because of the use of areca nuts in betel

leaves perhaps because of the publicised health benefits of the nut. But, there are several ill effects reported especially because of the addictive nature of the nut.

In 2012, WHO recognised betel nut use as a public health threat faced by the Western Pacific region. Feeling of wellbeing, mild euphoria, alertness, palpitations, faster heartbeat, high blood pressure, red face, sweating and feeling warm are some of the effects of betel nut as observed in people who regularly consume betel nut in any form.

According to the poisonous plant database by the United States Food and Drug Administration (FDA), betel nut eating or chewing is unsafe. Centers for Disease Control and Prevention (CDC) lists a host of health ill effects of consumption of betel nut with tobacco. These include oral sub-mucous fibrosis, oral cancer, addiction, reproductive problems and low birth weight in newborns. Oral sub-mucous fibrosis causes stiffness in the mouth resulting in restricted jaw movement.

High rates of oral and oesophageal cancer in people chewing betel quid with supari and tobacco have been reported. The slaked lime ('chuna') applied on the paan causes tiny abrasions in the mouth, which can be entry points for cancer-causing chemicals present in the betel nut. Continuous long-term chewing of betel nut can cause mouth ulcers, gum disease, tooth decay and permanent staining of teeth, turning red or black. Betel nut taken with tobacco or other medicinal drugs can be dangerous. Most people, who consume betel nut regularly, form dependence on the nut and have withdrawal symptoms.

Much research is required to fully understand the effects of long-term betel nut consumption on human health. There is no safe level of betel nut use. The effects of the nut vary in people. It all depends upon the size, weight and the health of the person who consumes it. The amount consumed is also of importance. Betel nut may also interact with other drugs or herbal supplements and there can be toxic reactions causing reduced effect of medications.

Consumption of betel nut and betel quid is associated with health problems and yet its use is still understudied. Even though India, Taiwan and Malaysia have large nut chewing populations, the topic is obscure and untouched.

It is true that men, women, adolescents and even children chew betel nut without knowing the consequences of its consumption. Aggressive public health measures need to be taken to bring awareness regarding its use and abuse.

Looking at the complex nature of betel nut addiction, strategies to discontinue its consumption are being designed. E-learning tools and social media may be utilised to educate masses regarding the use of betel nut and its related concerns. Misconceptions pertaining to the use of betel nut also need to be cleared. For long-term betel nut users, screening for oral cancer is the need of the hour.

Governments and health organisations across the globe have taken steps to create awareness regarding the risks of consuming betel nut. Taiwan has declared "Betel nut prevention day" to curb the consumption of the nut. Anyone spitting betel nut juice is sent to attend the betel nut withdrawal classes.

The Indian government has banned the use of nicotine and tobacco products and now the use of betel nut is prohibited in chewing tobacco products. Yet, we do not have any regulatory measures against the use of betel nut. In fact, there is no international policy for the control of areca nut use in spite of the risks it poses.

There is an urgent need to step up the regulation against the use of the nut products especially amongst the minors and adolescents who are most vulnerable to become dependent on the consumption of the nut. The nation needs a strict betel nut control programme.

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Ham Radio — Amateur Yet Critical Hobby

Tanmoy Deb, VU2TDV

Stamp on ham radio

HOBBIES range from reading books, singing, dancing, cooking, gardening, painting, collecting stamps, collecting coins, and so on. The list is as varied as human nature. It is a recreational activity without any commercial motive.

But there is one hobby that needs a license from the government! It is a very old hobby practiced in all countries in the world — and those practicing are called ham or radio amateurs. A licensed ham is allowed to converse freely with any ham in the world using High Frequency (HF) or Very High Frequency (VHF) radio transceiver (i.e. receiver and transmitter combined). It is very similar to a mobile handset which is also a radio transceiver. The difference is that the mobile phone operates on a chargeable basis while ham radio is free of cost.

A ham radio can operate on a wide variety of designated frequency spectrum. Although modern modes of communication such as WhatsApp, SMS, e-mail, voice calls, video calls, etc. have obscured ham radio, nevertheless, it still thrives the world over.

It is a two way radio communication that allows a ham to talk to any ham in the world without any charge. It is meant for private, recreational and non-commercial exchange of messages and emergency communication. The joy lies in making a radio contact with a complete stranger around the world. There are more than 3 million hams in the world. USA alone has 7 lakhs, Japan 3 lakhs, Germany 75000, UK 62000, Spain 59000, Canada 57000, Argentina 36000 and India 22000. The highest concentration of hams lies in the southern part of India followed by western, northern and eastern India.

The International Telecommunication Union (ITU), an agency of the United Nations Organisation, allocates frequency bands to hams. In India, Wireless Planning and Co-ordination wing (WPC) of the Department of Telecommunications under the Ministry of Communications conducts an exam, issues ham license and monitors communication traffic on air. It also allocates radio call signs to hams who are known by this call sign and not by their name when on-air. It is a unique alpha numeric code which identifies the country and the individual. VU2 and VU3 are assigned to India. Similarly, W for USA, VE for Canada, G for UK, DL for Germany, VK for Australia, 9M for Malaysia and so on.

Some of the celebrity hams are — Amitabh Bachchan (VU2AMY), Kamal Hassan (VU2HAS), Rajive Gandhi (VU2RG), Sonia Gandhi (VU2SON), Kalpana Chawla (KD5ESI), Yuri Gagarin (UA1LO) and Marlon Brando (FO5GJ).

Former Prime Minister Shri Rajive Gandhi (VU2RG)

History of Ham Radio

The history of ham radio goes back to more than a century. Long distance HAM radio communication began in the 1920s. In 1923, the first transatlantic radio contact was established between England and Connecticut.

In India, the credit for introduction of HAM radio goes to some officers of the Corps of Signals at Mhow, Madhya Pradesh in the 1920s. The first ham radio club was established by the name of Radio Club of India on 15 May 1948. Initially, Army personnel used to receive ham licenses. The first civilian ham license was issued to Amrendra Chandra Gooptu (VU2JK) in 1921. This was followed by Mukul Bose (VU2HQ) in the same year. In 1954, a group of hams formed the Amateur Radio Society of India (ARSI) in Delhi which was later shifted to Chennai.

The process of issue of license got interrupted during the world war. But, again picked up after the war.

The ham radio played a major role in India's freedom struggle. After the Quit India movement, the British government started clamping down on Indian freedom

fighters. To overcome media censorship, the Indian National Congress activists led by Usha Mehta contacted Mumbai-based ham Bob Tanna (VU2LK) to broadcast messages to grassroot workers in the country. This radio service was called Congress Radio. The radio started broadcasting from 2 September 1942 on 7.12 MHz frequency. But in November 1942, an unknown radio officer betrayed them and soon the radio station was forced to shut down.

Veteran freedom fighter Ms Usha Mehta

Ham Radio during Disasters

The ham radio plays a vital role as the second line of communication at the time of natural and manmade calamities such as storms, floods, cyclones, earthquakes, forest fires, train accidents, wars, tsunamis, etc. This is because during natural calamities, all normal channels of communication are disrupted. It is the ham community that comes forward and sets up temporary ham radio stations in affected areas thereby helping people, government machinery and aid disbursal agencies.

Some of the notable incidents of help provided by hams during disasters are listed below:

i. In 1960, during the Post & Telegraph strike, hams passed on messages for people rendering a free public service.
ii. In September 1979, the Machhu dam in Morbi, Gujarat burst triggering a flash flood. Hams in the cities of Rajkot, Baroda, Ahmedabad and Mumbai helped relief agencies, government officials and victims of disaster.
iii. During the Bhopal gas tragedy in 1984, hams setup a VHF (Very High Frequency) communication network in the city to help affected people.
iv. During the Latur earthquake in 1979, hams provided important communication link for the co-ordination of relief operations arranging medicine, food and clothing for the affected people.
v. During the Odisha cyclone, a ham radio station was operated from the chief minister's residence to maintain a hot link with New Delhi.
vi. In 1979, a 10 year boy from Thiruvananthapuram was suffering from a rare form of cancer and 20 vials of life saving medicine were needed. Indian hams established contact with Israeli, German and South African hams and the required medicine was eventually located in Rome, Italy. It was airlifted by Air India and the child's life was saved.
vii. In 1991, during the Gulf War, a lone Indian ham provided the only means of communication between stranded Indians and their relatives in India.
viii. Recently, during the ongoing Russia-Ukraine conflict, a ham from India got in touch with someone who informed that several Indian students were stuck up in a bunker, some 30 km from the city of Kiev. Indian hams contacted hams in Poland and Budapest who arranged for their evacuation.

The list is endless and includes the Peruman train accident (1988), Bhuj earthquake (2001), Thekkady boat disaster (2009), Sabarimala temple stampede (2011), Kashmir floods (2014) and so on.

Hams during a disaster

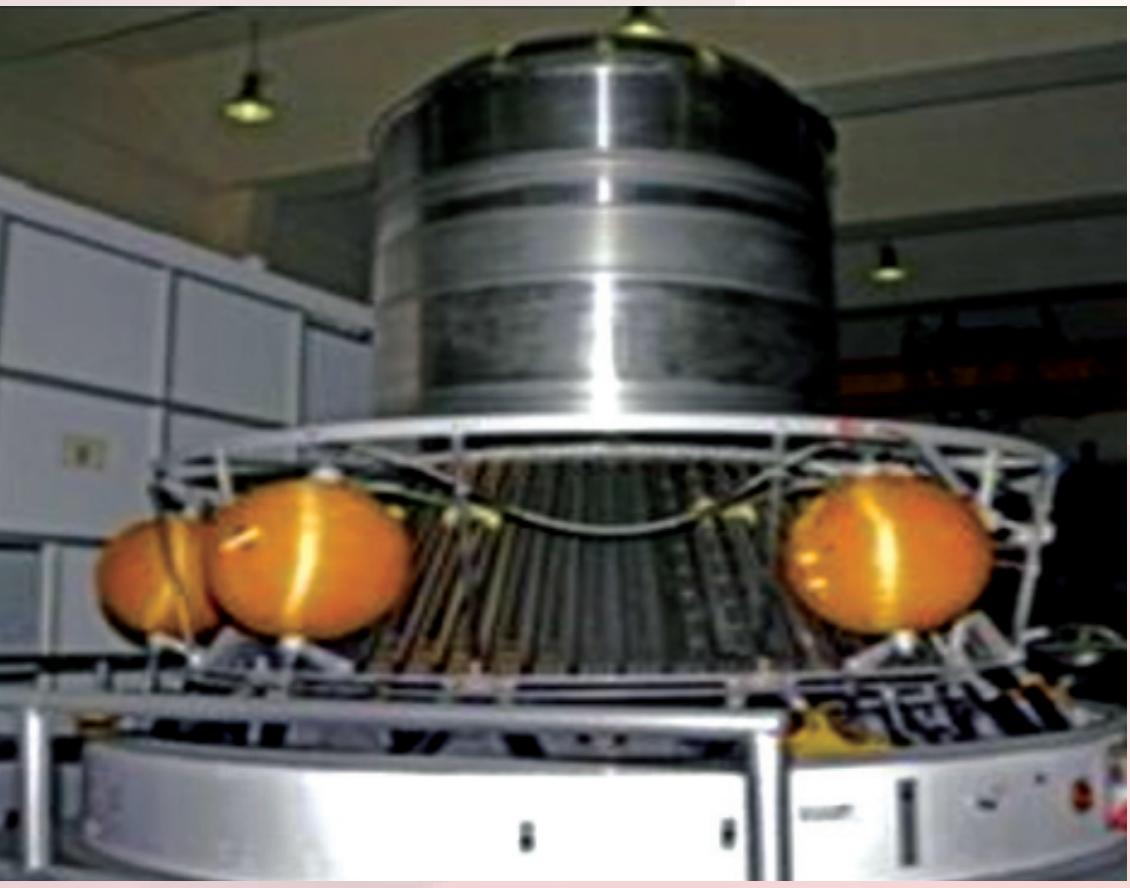
How do Hams Communicate?

Hams use speech, Morse code, slow scan TV, Fax, Satellite (OSCAR) for communication. They communicate on High Frequency (HF), Very High Frequency (VHF) and Ultra High Frequency (UHF) bands allotted by the International Telecommunication Union. In 2005, the Indian Space Research Organisation (ISRO) launched HAMSAT, an orbital satellite for ham communication. It was a microsatellite for amateur radio services launched on PSLV-6.

On 14 April 1989, Keki Darbary and Vilas Rabade accidentally made contact with Soviet cosmonaut aboard the orbiting space station MIR. The exchange lasted 3 minutes!

After getting license, a ham sets up his/her 'shack' or his work place which houses a HF/VHF transceiver, power supply and an antenna installed on the rooftop. Usually, one can either buy a radio transceiver (ICOM, YAESU, KENWOOD, ALINCO) or homebrew i.e. make own set from scrap sold by armed forces or take help from fellow HAM.

To stay active, hams form clubs and communicate with each other on a regular basis. This is known as Hamnet. They check into the net at predetermined time and date and chat in a group. National level events such as HAMfest,



AMSAT

HF set

JOTA (Jamboree on the Air — arranged by Bharat Scouts & Guides), contests, long distance expeditions, fox hunting (locating hidden emission using portable antenna), etc. are often organised.

Hams use language of their own on the air. Some commonly used abbreviations are listed below:

a. YL — Young Lady (unmarried female HAM)
b. XYL — Ex Young Lady (married HAM)
c. OM — Old Man (male HAM)
d. Crystal Control Ceremony — Marriage of HAM
e. Harmonics — Children
f. 73 — Bye Bye
g. WX — Weather
h. LL — Land Line
i. CW — Morse Code
j. QTH — Residence of HAM

A normal speech communication between two hams on air runs like this:

CQ CQ CQ this is VU2TDV on 20 m band and standing bye…
…Roger Roger this is VU2CCT… what is my report…
… 6 and 9 repeat 6 and 9. How is WX…
,,, WX fine… bright and sunny…
… I need some help….
…This is VU2TDV signing off for now…73 over and out.

The gist of the conversation is that one ham is looking for another ham to talk by identifying through their call signs. The report means quality of radio transmission (9 is excellent). To finish conversation, one says over and out.

VHF set

How to Become a Ham

The Licensing for ham is governed by:

i. Indian Telegraph Act, 1885.
ii. Indian Wireless Telegraph (Amateur Service) Rules, 1984, amendment 2009.

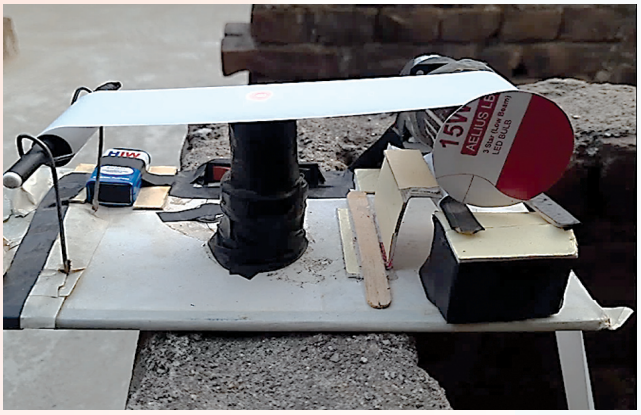
To become a ham, one has to pass an exam conducted by WPC, Department of Telecommunication. The test is on radio theory & practice, radio regulations, Morse code (sending and receiving). The person should be a citizen of India; age more than 12 years. There are two License categories: (i) Restricted grade (formerly grade-II) and (ii) General grade (formerly grade-I and advanced grade). The author VU2TDV received grade-I HAM license in 2002.

73… over and out.

Prof. (Dr) Tanmoy Deb is Professor and Head of Department of Electronics and Communication Engineering. He is an avid ham with radio call sign *VU2TDV*. Email: tdeb1969@gmail.com

BUILD YOUR OWN MUSIC-METER!

Kumar Gandharv Mishra



Physical model of the music-meter

THIS article is based on a model *'Visualising beats in a piece of music'*, which was selected for presentation in the National Innovation Fair 2016 by the National Science Centre, New Delhi. It tries to create a physical model (music-meter) to visualise the connection between mathematics & music in a hands-on manner.

There is an eternal connection between music and mathematics. Music can be described mathematically in various aspects such as permutation of notes, frequency, function of sine waves, beat tempo, etc. *(please see the cover article "Indian Classical Music — Mathematical Patterns that make it Soulful", Science Reporter, July 2023)*.

For many people the connection between music and mathematics often comes as a surprise. For most people, mathematics means numbers and equations. But there is also a 'measurement' aspect involved in music, especially classical music.

People often tap while enjoying music. So, the best way to convince them is through visualisation of their tapping gestures timestamp when they listen to beats in a music piece. To do this, I came up with the idea of marking the tappings on a running paper. The running paper acts as time in flow and the tappings get marked on the paper with time. So, the participant's tap has been recorded in a concrete form rather than abstract gestures. This often helps students and audiences visualise their markings on paper and then by measuring the distances between the markings they could get a sense of 'measurement' and hence 'numbers', and then connect it with mathematics.

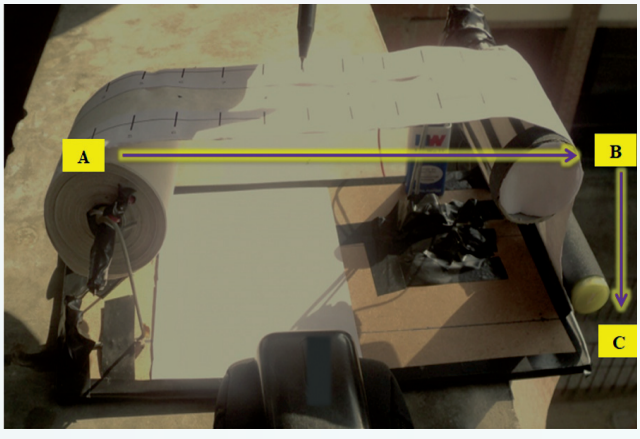
In this activity, the time-interval between two beats gets represented as a distance on the paper. The precision of markings also depends on the rhythmical ability of the participant. For example: some children are quick to identify a strong beat in the music while some struggle and mark beats haphazardly, but nevertheless it is a fun activity to engage with music consciously.

Now, a salient beat refers to the most noticeable and distinguishable beat among all beats (similar to a kind of percussion sound produced from a Tabla or drum — knock-knock or tik-tik sound). This beat has somewhat longer duration than other beats.

So, let's understand its working, and how to build it with simple things around you. What do you require? A wooden ply (30 cm x 20 cm approx.), a dc motor of 30 rpm, a paper roll (used in generating bills), a pen, two stands to support the pen in air, a red light for pointing on the paper, two cells; one for the motor and one for the light bulb, two switches — one for the dc motor and one for the cell, a cylindrical box equivalent to the size of paper roll, sand-paper and some cello tape.

Steps to build the music-meter

i. Mark two ends (A & B) on the plywood — one for the motor and one for the paper roll.



ii. Place the motor on one end with help of a stand, and place a pen with the support of stands on the other end with help of two poles such that the pen hangs on it, at equal height to the height of the motor.

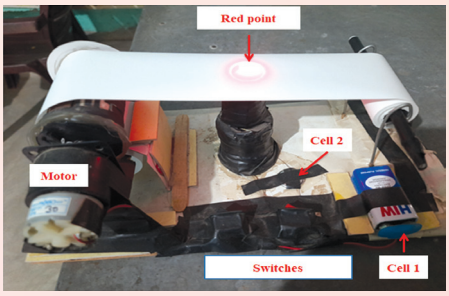
iii. Insert the pen into the paper roll such that the paper roll gets fixed on one end.

iv. Place the cylindrical box with the dc motor and stick some sand paper on the cylindrical box so that it can drag the paper placed on it (with help of friction).

v. Place some length of the paper on the cylindrical box from the paper roll such that it starts dragging the leftover paper roll when the motor is on.

vi. Place a red bulb/light in the middle of the two ends such that red light points on a specific position of the paper piece elongated between the two ends.

vii. Connect the dc motor and LED light with help of cells and switch.



viii. As soon as you switch on the motor, the paper starts translation movement with help of rotation of the motor. The paper keeps going out of the ply area. Place the whole structure on some height and let the paper fall down after each rotation.

ix. You may need to figure out how to translate (move) the paper by adjusting the friction between the paper and the cylindrical box so that the paper does translation movement. You may place an ice-cream stick on the lower side of the cylindrical box so that it touches the paper and eases the dragging process. You may figure it out according to your ease, but the ultimate goal is to drag the paper (horizontal movement from A to B) and with the help of motor and let it fall (vertical movement — downward from B to C).

Working Model

i. Play a music based on Teen Taal (16 beats cycle). Here is one sample link: https://youtu.be/wEHgiW-Hkng. (You can also search for music with simple beats on the internet and try those)

ii. Listen to this music for some time (1-2 minutes) so that you get conditioned to it and identify where you sense a strong beat. Once you get conditioned, your head will start nodding or fingers will start tapping.

iii. Once you have identified the pattern, switch on the motor and LED bulb. Make sure that the paper rolls smoothly over the motor.

iv. Switch on the music and start marking dots on the red point on the paper roll as soon as you listen to a strong beat (somehow you will also notice that you start sensing the upcoming beats and get ready to mark dots).

v. You may do this till the beat cycle ends, even 30 seconds are good enough.

vi. Switch off the motor and cut the paper from the end of the motor and collect the leftover paper roll with dots marked on it.

vii. Measure the distance between the dots (you need not use a ruler, you can measure it by folding the paper along the dots — which will give you an idea whether the marked dots appear at equal intervals (almost, barring some human errors) or not. Through a ruler you can find that the dots have appeared at some intervals (most probably approximately equal and integral intervals).

If this is the case (dots appear at almost equal intervals), then you probably have a great sense of rhythm. However, be aware that the dots appeared at equal intervals because the music was set so. If dots explicitly do not appear at equal intervals, it doesn't mean that you have bad sense of rhythm. It may be because beats were set up so in the music. Different people have different sense of beat; some may sense a particular sound as the salient beat while for some others the beat can be a salient beat in the same music. It is perceptual. For example, Teen Taal (Table1).

In Indian classical musical notation, X is the position where clapping is felt. X at 1 is known as first tali (clap) and it is the place musical composition meets the Tabla with a bang. It is also called 'Sam'.

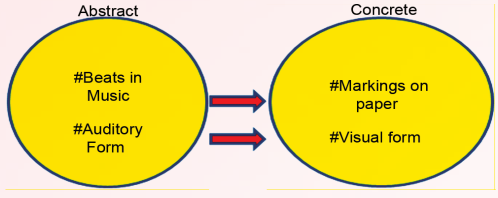
For the majority, Dha can be the salient beat, and they will always tap whenever Dha appears after a gap of three beats, while for some Dhin can be the salient beat or pick-up beat and they will tap or mark dots on paper whenever they listen to Dhin. It can be an interesting case to explore if a good piece of music has symmetry and beats at equal intervals in it or not.

viii. Repeat this activity with other tunes by increasing the complexity of beats. Try a different genre like Rap instrumental or *Snoop Dog, Pink Panther* and *Mission Impossible* instrumentals. You will find the salient beats appearing at equal intervals or in a specific pattern.

What's Happening?

As soon as the motor and lights are switched on, the roller on the motor starts dragging the paper from A to B, the paper does translation motion, and then from B to C it follows some circular motion and then vertical motion downwards. Infact the movement of paper is equivalent to the passage of time. The dot you mark on a specific point (red pointed light) on the running paper (time) is equivalent to the tap or gestures you make in air (abstract form) to a beat. So, your tap-stamps have got recorded on a paper unlike the abstract gestures with running time.

Now, you can play with these dot marks and measure the distance between the dots and look for patterns among these. So, the whole idea was to convert the abstract nature of tapping sense into visual & concrete form. It represents transformation of an abstract idea into concrete form.



Correspondence between beat sense in abstract and concrete form

Demonstration of the activity

1. Marking dots while listening to music

A children marking dots on the red point whenever they listen to a salient beat in the music

Table 1

Dha	*Dhin*	*Dhin*	*Dha*	*Dha*	*Dhin*	*Dhin*	*Dha*	*Dha*	*Tin*	*Tin*	*Ta*	*Ta*	*Dhin*	*Dhin*	*Dha*
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
X				*X*				*0*				*X*			

2. Cutting the paper roll after marking some dots

3. Holding the paper roll from both sides

This paper strip represents the total duration of beats of a specific tune in the form of length, when played with a motor of 30 rpm

4. Observing the dots through folding the paper at marked positions

Paper folding technique is a powerful way to measure the equivalence of distance between two points without support of any ruler. It can provide an estimation of half or double or unequal distance, and relationship between distances based on intuition rather than using a teaching-learning material like ruler.

5. Observing the dots by a ruler

6. Writing the measurements on the paper and understanding the connection

Educational Implications

This can be a fun activity for students to engage in a mathematics classroom, connecting art and mathematics. It may help to identify rhythmically challenged and abled children. It can also help in communicating a basic connection i.e. the time difference between beats (measurement in form of numbers and then their pattern) as one of the connections between music and mathematics to common public through visualisation and hands-on approach.

There might be some friction issues with rotation of paper roll, and beat rpm of the motor can get affected also by amount of paper roll getting reduced at the other end. Try to reduce these issues as far as possible.

A few interesting questions emerged while talking to children about their experiences while they engaged in this musical activity:

i. "Does good music have beats at equal intervals?"
ii. "There are so many beats. Which beat should I concentrate on?"
iii. What is a good piece of music?

Now, these are subjective questions for the readers. These questions are to be explored and investigated as these reflect the curious and reflective thinking of children. Hope you will come up with some answers while you make your own music-meter.

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SCIENCE FICTION

It's Not Dark Yet...

Monalisa Paul

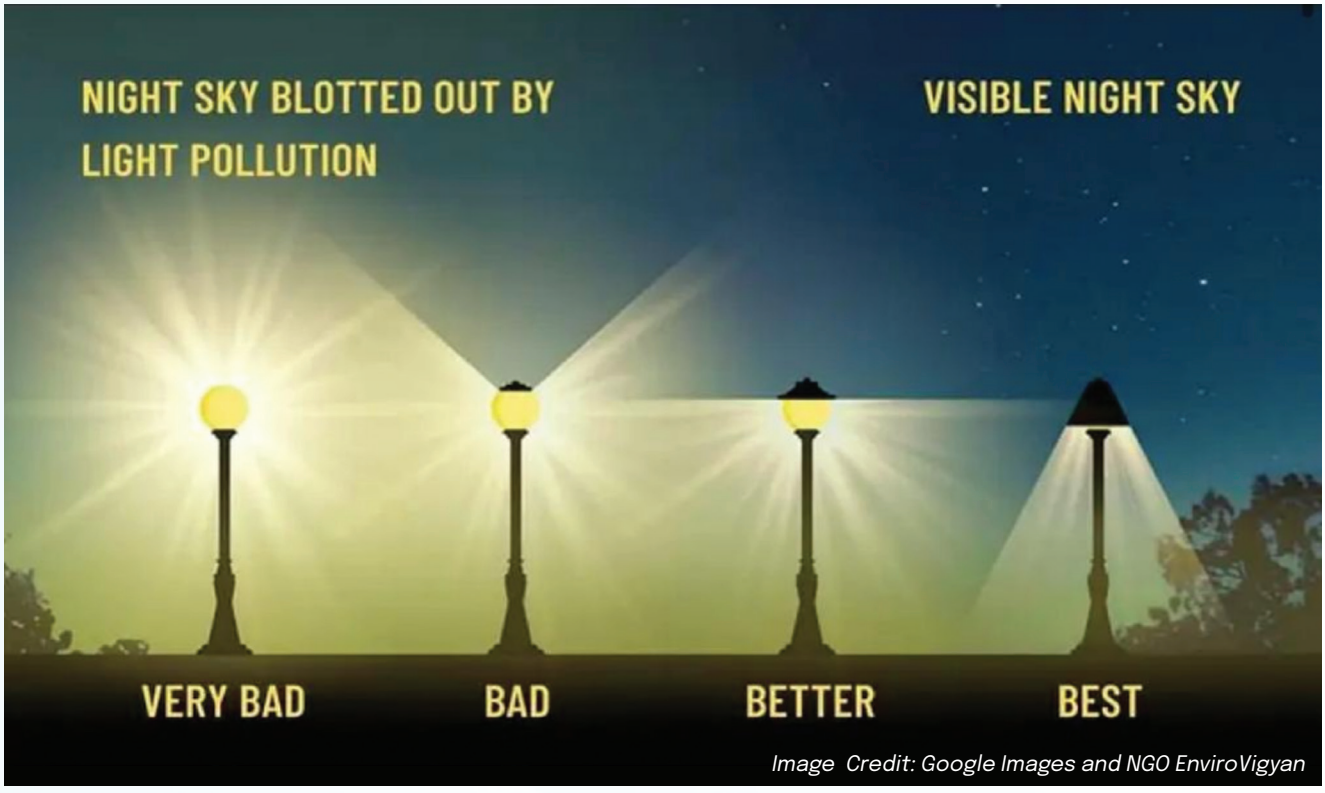

Image Credit: Google Images and NGO EnviroVigyan

BULBULI was roaming outside the house. More than half an hour has passed since it was twilight. The sky was dazzling and everything was clearly visible to Bulbuli. Mother was anxious. She was on the porch waiting for her daughter to come back soon. She called her several times, and when Bulbuli did not listen, she screamed aloud, "Bulbuli, it's dark. Come back home."

Bulbuli was startled by her mother's voice, but she replied, "Mother, two minutes, please. I will be right back." She was enjoying the view and not at all bothered to go back home.

The mother then mellowed down and called out softly, "Dear please come back home. It's rooster time. Look, all the birds are returning to their nests. You should too."

Finally, Bulbuli flew back her home half-heartedly and asked her mother impatiently, "Mother! Why did you call me so early? It's not dark yet. It is bright outside."

Mother thoughtfully explained to Bulbuli, "It is not the natural light dear. The sun set almost an hour ago. Twilight passed as well. It's time to have dinner and go to bed."

But Bulbuli said, "Go to bed so early? See the sky. I will remain awake till father and brother return."

Mother then gave a scientific explanation, "This is not the natural light, but an artificial glow created by humans so that they can work efficiently at night when there is no sun. You know, as the greed of humans grew, they created electric light bulbs for working late during the night hours. They are now innovating more dazzling lights. Their routine has been completely altered. Most of them sleep till afternoon and remain awake during the night. Humans can use outdoor lighting whenever and wherever it is needed. They can use the lowest light level when required, limit blue-violet light, utilise timers or motion sensors or can use shielding but they barely care."

Mother paused a bit. As she gathered her thoughts, she could see the disagreement in the eyes of her daughter. She continued, "Every day the sun rises at a particular time and then sets. The time interval in between two events is called a photoperiod. These humans have created lights stretching the photoperiod, which is harmful for our circadian rhythm. It affects our physiology and psychology gravely. This man-made radiance is creating ecological pollution in the form of ALAN (Artificial Light At Night)."

While mother was busy explaining the ill effects of light pollution, Bulbuli was engrossed in the glow of the city lights. Her gaze was interrupted by the flapping of her father's wing, who had flown back home just now after a long day of search!

Image Credit: Google Images and NGO EnviroVigyan

His first question to her mother was, "Are the kids back home? It is already dark."

"Our daughter is back but our son is still hovering around," mother replied sheepishly.

"I asked you strictly to keep a check on him and his flying activities. He is going astray. This light pollution is not good for kids. He does not sleep on time, nor does he wake up on time. We are birds. We have a responsibility in maintaining the ecological equilibrium," father spoke sternly.

Mother distracted him with a question, "How was your day? Did you find anything suitable? Any new nest in the dark corners? What did the nest dealer say?"

"I am trying my best. The nest taxes are rising day by day. Dealers are showing me the ready-to-move in nests, but they are in the commercial areas of the city which are well lit at night. The penthouse nests are on the outskirts of the city which are beyond our reach. Humans have not kept a single nook light-free," father said disheartened.

"Can we buy a tree of our own where we can build a nest of our own? It will be a future investment," suggested mother.

"TREE!" exclaimed father. "Humans are ruthlessly cutting them. Not even one is left in the city. In the name of plantation, they are planting ornamental palm trees which neither give shade nor fruits to our fellow birds and monkeys nor can we build nests on them. There are few trees which are out of the city limits and have been already booked for higher bidding."

Mother was sad. Father was worried. Bulbuli was oblivious to the gravity of the situation. She was awestruck by the glamour of artificial light.

The bird parents could correlate the depth of the situation with past few incidents. Many of their fraternity members were losing orientation while migrating. Many had been lost now. They could not reach the target site at the time and change of season and lost the chance of mating, breeding and survival. Artificial illumination distracted their natural pathway. They kept on hovering over these lights, got exhausted and were trapped by hunters or high-rise buildings. Their mating calls have differed as they are not clear about the day and night distinction. Recently their distant friend Mimi, a turtle, was confused during the breeding season due to sky glow. Many of her colleagues' kids, when they hatched out of the eggs, rushed towards the city lights instead of going to the oceans, mistaking them for sunlight. Another friend, Jimmy the frog, is now addicted to artificial lights like human kids to the mobile phone screens.

As parents were reminiscing about the bioluminescence of the past when glow flies and fireflies used to light up the dark, their son arrived. Before father could start lecturing him, Babla broke the news.

"Father, I have found a place for our new home," said the panting Babla. "It is green. It is dark after sunset. No human intervention." Before he could finish his description, Father interrupted, "Are you sure?"

"Yes Father. I am. The Banyan trees of sacred groves have promised me to provide us shelter. They have been able to survive due to the attached spiritual connotations. People do not cut them. The best part is that even the environmentalists are safeguarding the place to preserve the ecological traditional knowledge. We will move to the two-nest room set tomorrow morning itself. I had sleepless nights for all this time as I was busy searching for a good place to shift over. Sorry father if you felt otherwise."

As Babla continued to speak, the father felt very proud of his son who was a responsible bird now. Bulbuli came closer to her family, looked into her parent's eyes, yawned, and fell asleep immediately. The parents breathed a sigh of relief. Now their family was safe, kids were safe from the side effects of artificial illumination.

As the night darkened, the three of them gazed towards the city lights and looked into each other's eyes, as if saying: "It is not dark yet."

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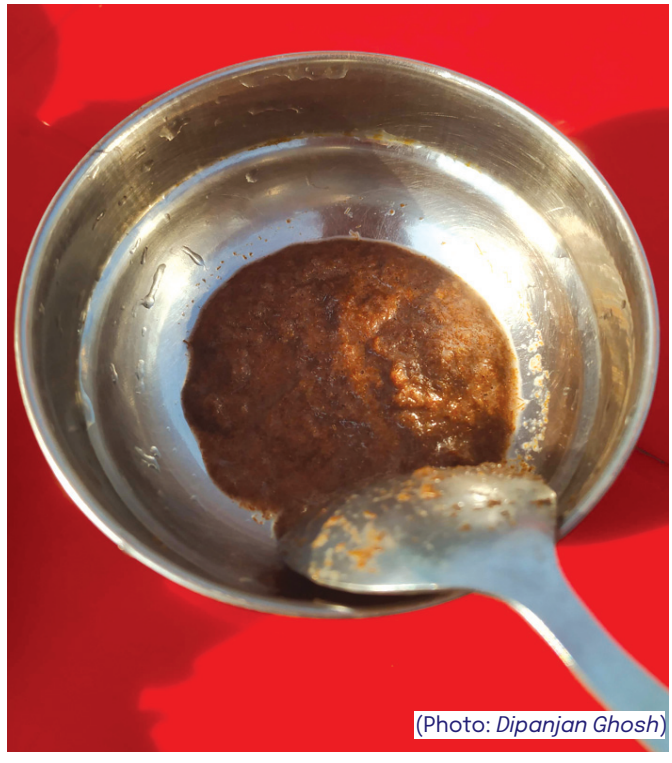
KURKUT — A TRIBAL DELICACY

Dipanjan Ghosh

Red weaver ants (*Oecophylla smaragdina*) are eusocial arboreal ants that aggressively defend their territories against intruders



Freshly prepared '*Kurkut*' is an all-time favourite tribal delicacy

A section of the people living in the jungle areas of Jangalmahal, in the south western parts of West Bengal, earn their livelihood by collecting red ants and their eggs from the forest. These red ants are called *'kurkut'* in the local language. They use larval silk to weave together leaves to form their nesting cavities. That is why red ants are commonly called 'weaver ants'.

Red weaver ants or *kurkut (Oecophylla smaragdina)* are aggressive arboreal ants with size ranging from 8-10 millimetres. Their skin colour is copper-brown and their head and belly are relatively dark black.

These red ants are social animals. Both queen and male ants have wings. After mating, the queen ant sheds its wings and builds a new nest with worker ants without the help of the male ants. Male ants usually die after mating. A queen ant can lay eggs for many years. Most of the larvae that hatch from the eggs later become worker ants. Small-sized workers and infertile female ants provide the necessary food and other provisions inside the nest.

These red ants are omnivorous in their diet. They hunt small insects such as termites and eat various parts of plants, nectars, etc., chiefly for juices. However, they can't eat solid food. Like spiders, they first liquefy solid food by special chemical methods and then eat it.

Weaver ants are an all-time favourite tribal delicacy of the hills and jungles throughout India mainly as a protein source since the ants (especially the ant larvae) are rich in high protein, fatty acids, calcium and vitamin C contents. For entomophagy, these ants and their eggs are battered with salt, ginger, green chillies and mustard oil to make a sour, quick and tasty pickle or *'chokha'* and eaten with rice. For people who are unable to meet their daily protein requirements, for them this sour-tasting *kurkut* (red ant chutney) is a priceless nutritional gift of wild nature. At one time, the infamous Amlasol, in the Jhargram district where people had been starving for a long time, made headlines as *kurkut* became the only means of survival for the inhabitants.

They live inside a nest that has no specific entry or exit holes. Such nests are usually built in the green leaves of tall and large leafy trees such as Sal *(Shorea robusta)*, Mango *(Mangifera indica)*, Piasal *(Pterocarpus marsupium)*, Arjun *(Terminalia arjuna)*, etc., covered with sticky liquid secreted from the salivary glands of their larvae and cobwebs to look like paper-bags. They also stay safe from forest fires by building their nests on tall trees in the forest. Nesting is most common in winter. Their nest is called *'kurkut potam'* in the local language. Weaver ants often build large nests for their own needs. One can find different sizes of ants residing in a single nest. There are thousands of ants in each nest.

A mature colony of weaver ants can dominate a tree with nests distributed throughout their heavily defended arboreal territory

A *kurkut* collector using a long bamboo pole with a bag to the tip

The red ants are well known for their aggressive behaviour. Their bite is very painful and a sharp burning sensation is felt after the bite. However, red ants do not have a stinger. They bite very hard and the formic acid in their abdomen causes excruciating burning and pain at the bite site. Ignoring this terrible bite, the people of the forest have been collecting their nests from morning to afternoon for a long time. During the winter months, i.e., from November to February, people collect *kurkut* by climbing trees or by using a long bamboo pole with a bag or basket attached with strings to the tip. A hole is poked into the nest with the tip of the pole and it is shaken. In this way, larvae and pupae fall into the bag. The content of the bag is poured into a big plastic container in which some rice and wheat flour is added to prevent the ants from climbing and escaping. A branch is inserted into the container so that adult ants can climb up. Then, the branch is whipped against a tree to release them and the larvae and pupae left in the bag are collected for human consumption.

In addition, *kurkut* has many medicinal uses. Traditional healers prescribe hot soup of battered kurkut with ginger, garlic, salt and boiled like tea to get rid of accumulated phlegm. Besides, *kurkut* is also used for constipation and stomach cleansing. Taking *kurkut* chutney regularly is said to protect from common ailments like fever, chills, colds and coughs. Its regular consumption is claimed to increase the immunity and temperature of the body, so people never seem to feel cold during winter. Moreover, traditional healers believe that regular intake of *kurkut* will prevent rheumatism. They also prepare oils in which they dip collected weaver ants. After six weeks, oils are used externally to cure rheumatism, gout, ringworm or other skin diseases, or else as an aphrodisiac.

Vendor selling ant larvae and eggs in a village haat

Due to their predatory habit red ants are also recognised as biological control agents in tropical tree crops as they can protect a variety of crops against many different insect pests. In this way, they are used indirectly as an alternative to chemical insecticides. In our country, it is a very popular bait for fishing. The larvae of weaver ants are also collected commercially as an expensive feed for insect-eating birds in Indonesia.

Red weaver ants also have significant roles as a means of livelihood for the people of Jangalmahal. These are sold live in the market. The eggs of *kurkut* wrapped in green Sal leaves are sold in weekly village haats. Also, people store sundried ants in containers for selling them at high prices during the off-season when these ants are not found in the forest.

Dipanjan Ghosh is a popular science writer and one of the Editors of the journal *'Indian Science Cruiser'* published from Kolkata. Email: dpanjanghosh@gmail.com

AI-based model to Predict Knee Osteoarthritis Severity from X-ray Images

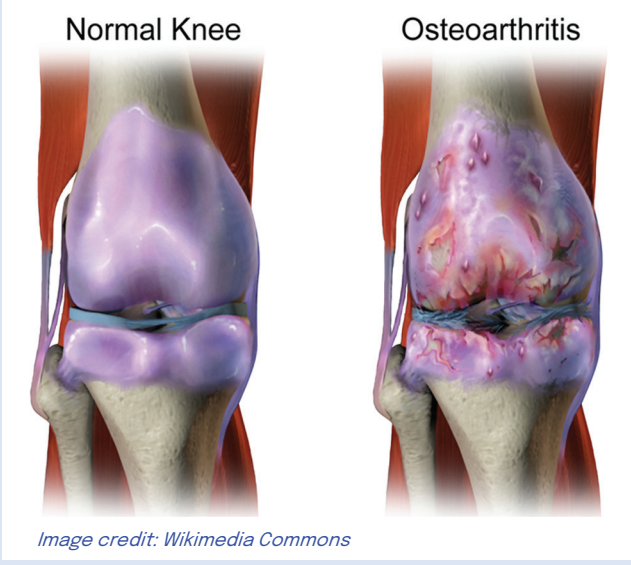


Image credit: Wikimedia Commons

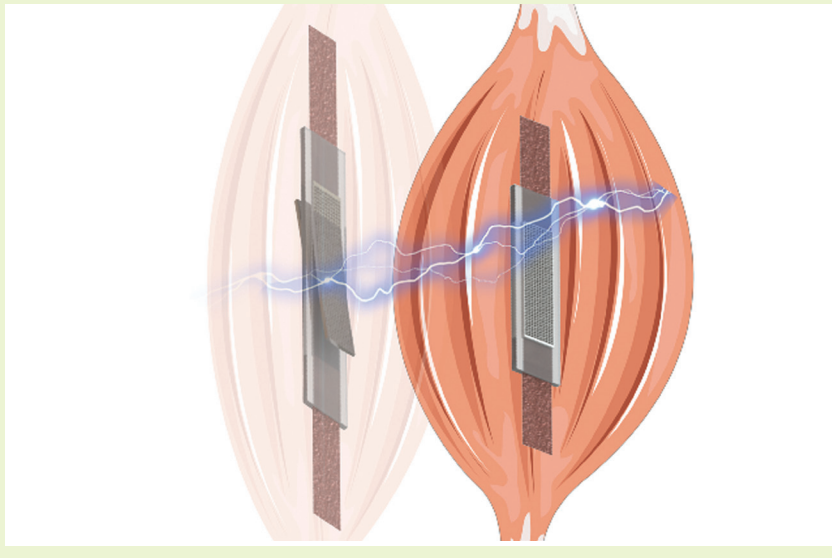
KNEE Osteoarthritis is the most common musculoskeletal disorder in the world and has a prevalence of 28% in India. There is no possible cure for Knee OA except total joint replacement at an advanced stage hence an early diagnosis is essential for pain management and behavioral corrections.

Therefore, researchers from the Indian Institute of Technology Guwahati have developed a Deep Learning (DL)-based framework, namely Osteo HRNet that automatically assesses the Knee Osteoarthritis (OA) severity from X-ray images.

This AI-based model can be used to detect the severity level of the disease and assist medical practitioners remotely for a more accurate diagnosis. The research has been published in the journal *Multimedia Tools and Applications*

Source: IIT Guwahati Press Release

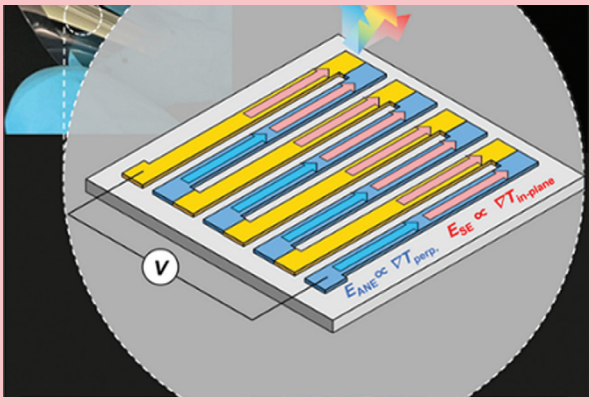
Self-Sensing Electric Artificial Muscles



RESEARCHERS from Queen Mary University of London have developed a durable and flexible new type of electric variable-stiffness artificial muscle that has self-sensing capabilities. This revolutionary artificial muscle exhibits flexibility and stretchability similar to natural muscles capable of adapting to various shapes. It can also rapidly adjust its stiffness by applying different voltages. The innovative technology has various applications, from soft robotics to medical applications. The study was published in *Advanced Intelligent Systems*.

Source: Queen Mary University of London News

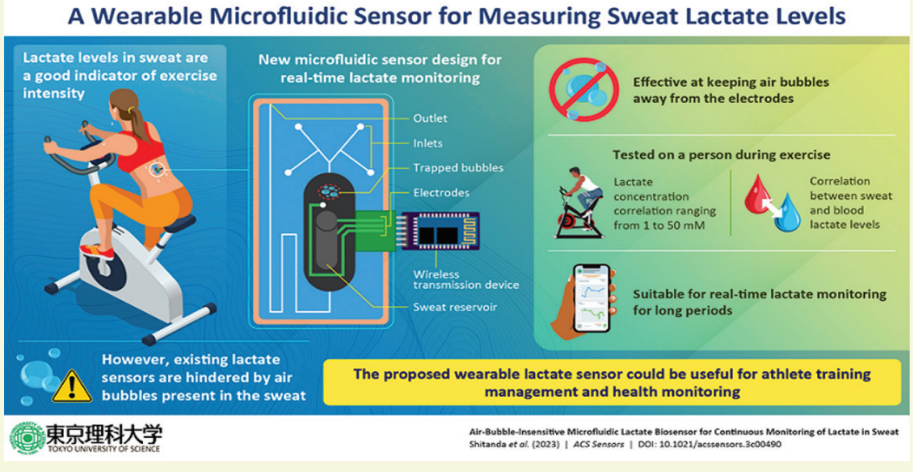
Sensor Novel Thermal Sensor



EXCESS heat from electronic or mechanical devices is a sign or cause of inefficient performance. In many cases, embedded sensors to monitor the flow of heat could help engineers alter device behaviour or designs to improve their efficiency. For the first time, researchers exploit a novel thermoelectric phenomenon to build a thin sensor that can visualise heat flow in real-time. The sensor could be built deep inside devices where other kinds of sensors are impractical. It is also quick, cheap and easy to manufacture using well-established methods. The study was published in *Advanced Materials*.

Source: University of Tokyo Press Release

Innovative Wearable Sensor for Measuring Sweat Lactate Levels during Exercise


A Wearable Microfluidic Sensor for Measuring Sweat Lactate Levels
Lactate levels in sweat are a good indicator of exercise intensity
New microfluidic sensor design for real-time lactate monitoring
Outlet
Inlets
Trapped bubbles
Electrodes
Wireless transmission device
Sweat reservoir
Effective at keeping air bubbles away from the electrodes
Tested on a person during exercise
Lactate concentration correlation ranging from 1 to 50 mM
Correlation between sweat and blood lactate levels
Suitable for real-time lactate monitoring for long periods
However, existing lactate sensors are hindered by air bubbles present in the sweat
The proposed wearable lactate sensor could be useful for athlete training management and health monitoring
東京理科大学
TOKYO UNIVERSITY OF SCIENCE
Air-Bubble-Insensitive Microfluidic Lactate Biosensor for Continuous Monitoring of Lactate in Sweat
Shitanda et al. (2023) | ACS Sensors | DOI: 10.1021/acssensors.3c00490

WEARABLE microfluidic sensors can be used to monitor lactate concentration in sweat, a good indicator of exercise intensity. However, air bubbles present in the sweat can get into the microfluidic channels, hindering the measurement. In a recent study, researchers from Japan have developed a wearable sensor for continuously monitoring sweat lactate during exercise, which incorporates a bubble-trapping region in its microfluidic system. The proposed technology can facilitate athlete training management and health monitoring. The study was published in *ACS Sensors*.

Source: Tokyo University of Science Press Release

TEST YOUR KNOWLEDGE

KNOW ABOUT PROTOPLAST

Sanjeeb Kumar Das

1. **Protoplasts are plant cells with a plasma membrane but no _____.**
   a) Cell wall
   b) Ribosome
   c) Mitochondria
   d) None of the above

2. **Protoplast is counted by _____.**
   a) Hemocytometer
   b) Protocytometer
   c) Gigermuller counter
   d) None

3. **Intact protoplasts from a pellet. This statement is_____.**
   a) False
   b) True
   c) Not known
   d) None

4. **Protoplast is a _____ individual cell.**
   a) Functional
   b) Non Functional
   c) Not Known
   d) None

5. **The word protoplast was coined by _____.**
   a) Hanstein
   b) Klercker
   c) Cocking
   d) Tkebe et al

6. **To isolate protoplast, one needs _____.**
   a) Pectinase
   b) Cellulase
   c) Both Pectinase & Cellulase
   d) Chitinase

7. **Which of the following is correct about Cybrid?**
   a) Genomes of two different plants
   b) Cytoplasms of two different plants
   c) Genomes and Cytoplasms of two different plants
   d) Cytoplasms of two different plants & the genome of one plant

8. **The contact of the protoplast depends on the surface _____.**
   a) Charge
   b) Permeability
   c) Heat
   d) None

9. **Which of the following scientists tried to isolate protoplast from plasmolysed higher plant cells by mechanically cutting the cells?**
   a) Takabe
   b) Klercker
   c) Carlson
   d) None

10. **_____ is used to check the viability of the protoplast.**
    a) Phenosafranine staining
    b) Fluorescein Diacetate (FDA) staining
    c) Both “a” and “b”
    d) Only “a”

11. **Protoplasts from actively growing cell cultures require high _____.**
    a) Auxin/Kinetin
    b) Kinetin/Auxin

c) Auxin= Kinetin

d) None

12. The first intergeneric hybrid (Pomato) between Potato and Tomato was demonstrated by _____.

a) Melchers

b) Zelcer

c) Carlson

d) Takabe

13. The fusion and fusion product of protoplast is observed in _____.

a) Electron Microscope

b) Compound Microscope

c) Phase Contrast Microscope

d) Inverted Microscope

14. There are several chemical and physical agents known as fusogens which help in fusion between protoplasts. These are _____.

a) Sodium Nitrate

b) Polyethylene Glycol

c) Dextran Sulphate

d) All

15. In some species, protoplasts can directly form somatic embryos, These are _____.

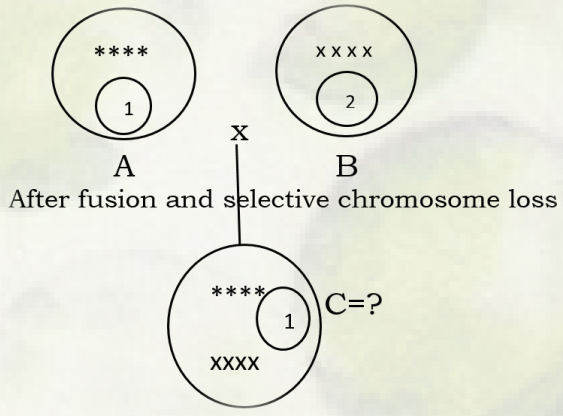
a) Medicago

b) *Brassica juncea*

c) Citrus

d) All

16.



In the diagram, find C=?

a) C=Heterokaryon

b) C=Cybrid

c) Both

d) None

17. Somatic hybrids are produced by _____.

a) Protoplast fusion

b) Tissue culture

c) Pollen culture

d) Hybridoma process

18. The enzyme used for the isolation of protoplast is _____.

a) Amylase

b) Cellulase

c) Catalase

d) All

19. The most suitable source for protoplast isolation in plants is _____.

a) Leaf

b) Stem tip

c) Lateral meristem

d) Apical meristem

20. For culturing Protoplast, which media is generally used?

a) Natural media

b) Nutritional media

c) Differential media

d) Artificial media

Answers

1.a	2.a	3.b	4.a	5.a	6.c	7.d	8.a
9.b	10.c	11.a	12.a	13.d	14.d	15.d	16.b
17.a	18.b	19.a	20.b				

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Gazing at the night sky!

Two friends, Avi and Arsh, were gazing at the night sky when they spotted a shooting star, filling them with joy and wonder. They started talking about space rocks, and then Avi challenged Arsh to guess the answer to a space rock puzzle.

a. Hey! I am a small rocky body orbiting around the sun. Sometimes I am referred to as "Minor Planet". But do you know, I am a very ancient remnant from the early days of the solar system. Do you know who I am?

b. At times, when I (answer of a) collide with another me, I shatter into small pieces. I may also originate from Mr Comet. So guess who I am?

c. I am not actually a star but am sometimes referred to as a "shooting star". When Mr B (answer of b) enters earth's atmosphere without being vapourised, I appear as a streak of light in the sky. Can you guess who I am?

d. Sometimes, when Mr B (answer of B) doesn't fully vapourise in the atmosphere and instead lands on Earth's surface, it becomes me. Can you guess who I am?

e. Like Mr A (answer of a), I, too, orbit the sun, but I am not a rock. Instead, I am made of dust and ice. When my ice and dust vaporise as I get closer to the sun, I develop a tail. Can you guess my name?

Restoration!

Image credit: Pexels

As Roopa was watching the news, something caught her attention. She turned to her elder sister with a curious look and asked, “Didi, what is this ‘Biorock Technology’ they’re talking about?” in the news. Her sister explained to her that this technology is all about restoring the damaged _____ by using mineral accretion. Now find out what this technology is restoring.

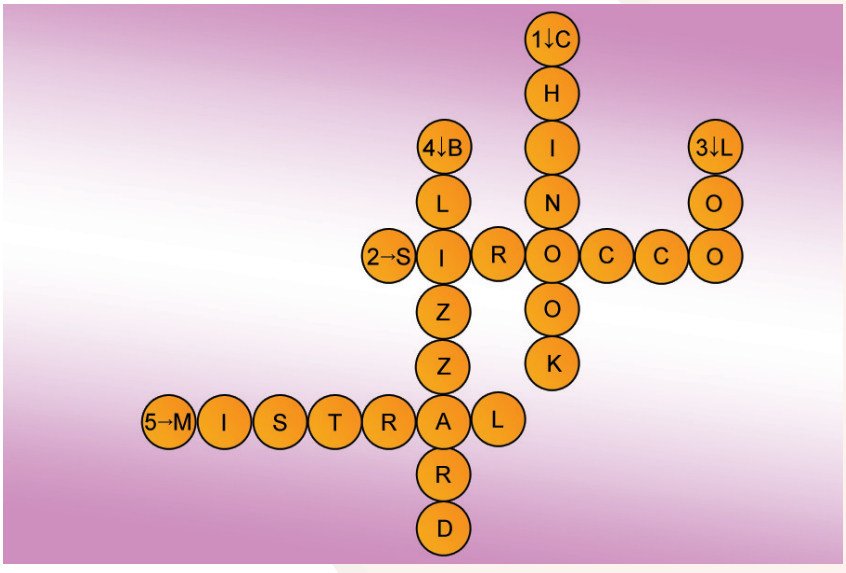
SOLUTIONS TO THE PUZZLES PUBLISHED IN AUGUST 2023

There is nothing like Joy! It’s too Scary...

Answer: Biparjoy Cyclone

Fill the Grid

Name the local winds based on their geographical locations



Online Biodiversity Drawing Competition 2020

Theme — "Conserve Biodiversity to Preserve Humanity"

Group I (Class V-VIII)

Go Green
THERE IS NO PLANET B
"Biodiversity is the key for more varieties"
Biodiversity is the unity of life unity is strength

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